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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES FERTILIZER INDUSTRY

DEVELOPMENT PLANNING AND RESEARCH ASSOCIATES,
INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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7. Author(s)
Milton L. David, J. M. Malk, C. Clyde Jones

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The nitrogen and phosphate fertilizer industry, SIC 2873 and 2874, studied herein involved five segments of 312 plants. The industry has experienced cyclical earnings and even with the higher prices of 1972, return on equity ranks well below the average manufacturing performance. Nitrogen capacity is growing slower than demand, whereas phosphate capacity is expected to expand faster than demand.

Nitrogen producers are expected to pass along control costs with higher prices, excepting the ammonium nitrate segment which has high control costs. The phosphate segment is expected to pass along a portion of control costs, limited by costs of larger producers and in-place pollution control facilities.

Closures due to pollution control, are projected to be under one percent of capacity in the ammonia segment, 16 to 24 percent in ammonium nitrate, and two to ten percent in the urea segment. In the phosphate segments, projected closures are

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nine to 19 percent of the ammonium phosphate capacity and two to 10 percent of superphosphate capacity.

External impacts on employment and community are not expected to be large, as the industry is capital intensive. Pollution impacts on foreign trade of fertilizer is not expected to be as great as with other factors.

EPA - 230/2-74-010

ECONOMIC ANALYSIS OF
EFFLUENT GUIDELINES FERTILIZER INDUSTRY

Milton L. David
J. M. Malk
C. Clyde Jones

January, 1974

Prepared for
Office of Planning and Evaluation
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This report has been reviewed by the Office of Planning and Evaluation, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

PREFACE

The attached document is a contractor's study prepared with the supervision and review of the Office of Planning and Evaluation of the U. S. Environmental Protection Agency (EPA). Its purpose is to provide a basis for evaluating the potential economic impact of effluent limitations guidelines and standards of performance established by EPA pursuant to sections 304(b) and 306 of the Federal Water Pollution Control Act.

The study supplements an EPA technical "Development Document" issued in conjunction with the promulgation of guidelines and standards for point sources within this industry category. The Development Document surveys existing and potential waste treatment and control methods and technologies within this category and presents the investment and operating costs associated with various control technologies. This study supplements that analysis by estimating the broader economic effects (including product price increases, continued viability of effected plants, industry growth and foreign trade) of the required application of certain of these control technologies.

This study has been submitted in fulfillment of Contract No. 68-01-1533, Task No. 6 by Development Planning and Research Associates, Inc. Work was completed as of January, 1974. The study is based primarily upon an earlier study, also prepared by Development Planning and Research Associates, Inc. entitled Economic Impact of Costs of Proposed Effluent Limitation Guidelines for the Fertilizer Industry.

The earlier report was circulated in conjunction with the publication in the Federal Register of a notice of proposed rulemaking under sections 304(b) and 306 for the subject point source category. The analysis contained in the original study has been revised based upon information received during the period of time between publication of the notice of proposed rulemaking and the promulgation of the final regulation. Because of the constraints of time, the control and treatment costs analyzed in this study may not in all instances be identical to those associated with the requirements of the promulgated regulation. However, those differences, when they exist, are minor insofar as the final conclusions of the study are concerned.

This report represents the conclusions of the contractors. It has been reviewed by the Office of Planning and Evaluation and approved for publication. Approval does not signify that the contents necessarily reflect the views of the Environmental Protection Agency. The study has been considered, together with the Development Document, information received in the form of public comments on the proposed regulation, and other materials in the establishment of final effluent limitations guidelines and standards of performance.

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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES FERTILIZER INDUSTRY

EXECUTIVE SUMMARY

INTRODUCTION

This report on the basic fertilizer chemicals segment of the fertilizer manufacturing industry analyzes the economic impacts of water pollution controls. It is one of a series of studies prepared under the supervision and review of the Office of Plannining and Evaluation, U. S. Environmental Protection Agency, as required by the Federal Water Pollution Control Act Amendments of 1972.

Under the provisions of Sections 304 and 306 of the Federal Water Pollution Control Act, EPA has proposed effluent guidelines for basic fertilizer chemicals plants. The purpose of this study is the evaluation of potential economic impacts resulting from the implementation of the effluent guidelines.

The evaluation approach utilized is generally one of describing and analyzing the industry in terms of structure; number and types of firms and plants; location, age and technology of plants; financial data for model or representative plants; and pricing practices and supply-demand relationships. Then, pollution control costs are superimposed on the model plant profiles to determine micro-economic effects, such as price increases expected and potential closures. Macro impacts on the industry are then analyzed for effects on employment, communities, balance of payments and related matters.

In gathering data for the study, industry sources proved valuable in supplying descriptive material about firms and plants. Published governmental and private reports provided additional information for both micro and macro analysis.

I. INDUSTRY SEGMENTS

The fertilizer industry includes two broad classifications of products:

SIC 2873	Nitrogeneous fertilizers
SIC 2874	Phosphatic fertilizers

This report is limited to the following products:

Nitrogeneous fertilizers
- Ammonia
- Ammonium nitrate
- Urea

Phosphatic fertilizers
- Wet-process phosphoric acid (intermediate)
- Diammonium phosphate
- Triple superphosphate
- Normal superphosphate

The basic fertilizer chemicals industry is dominated by large, integrated, diversified corporations, most of which are chemical or petrochemical manufacturers. Many of the largest producers of fertilizers realize only a minor portion of their gross sales revenues from fertilizer sales. Furthermore, there is much horizontal and vertical integration. Approximately 85 percent of the basic products plants are in multiplant complexes. Although precise data on vertical integration are not available, there is widespread backward integration among the large producers; forward integration into retail distribution also exists, with about 25 percent of retail sales attributed to basic producers' outlets.

In addition to large, diversified corporations, basic fertilizer chemicals are produced by some cooperatives (which may also be integrated and diversified), by some small, specialized chemical companies, and by manufacturers of unrelated products who produce fertilizer chemicals as by-products.

There are 109 firms producing basic chemicals, plus nine non-basic producers of normal superphosphate. The ten largest firms in each product category account for 44 to 71 percent (excluding the superphosphates, where fewer firms exist) of the U. S. product capacity.

These 118 companies operate 327 plants throughout the United States. The number of plants and capacities by product are as follows:

Product	Number of Plants	Number of Firms	Estimated Capacity (000 tons per year)
Ammonia	83	57	16,888
Ammonium nitrate	54	36	7,192
Urea	42	35	4,363
Phosphoric acid	32	26	6,370 1/
Diammonium phosphate	41	32	3,681 1/
Triple superphosphate	15	13	1,882 1/
Normal superphosphate	60	27	735 1/

1/ 1,000 tons of P_2O_5.

Plants vary by age, size and technology. In most of the product subcategories, the majority of plants are small but the large plants account for most of the production. For example, 27 percent of the ammonia plants account for 54 percent of the capacity; only 8 percent of the plants have 23 percent of the capacity. Twenty-two percent of the phosphoric acid plants have 52 percent of the capacity. Ammonium nitrate has a high number of small plants--70 percent with 44 percent of capacity; the largest sized plants (13 percent of all plants) have 32 percent of capacity. Other segments have similar distributions. As a general rule, smaller plants are the older ones, using older and less efficient technologies.

As to location, plants in the nitrogen subcategory are both raw material and market oriented, while phosphate plants are largely raw material oriented. About half of all ammonia plants are in the Texas-Louisiana Gulf Coast region near natural gas sources; the West North Central states also have a heavy concentration of ammonia plants which are near their markets. Phosphoric acid plants are concentrated in Florida near the major phosphatic rock deposits. Plants for other products are located generally adjacent to the basic intermediate products (ammonia and phosphoric acid).

On the whole, basic fertilizer chemical plants employ a high-level technology. Assets per employee average $80,200, which ranks third among all U. S. industries. Also, the industry has relatively high productivity, with average sales per employee of $62,400, which also ranks third nationally. Total sales (retail) amounted to about $2.9 billion in 1972.

The fertilizer industry as a whole employs approximately 40,000 to 45,000 persons. The 327 plants in this study have an estimated 10,290 employees, or about 22 to 25 percent of the industry's total.

II. FINANCIAL PROFILE

In the absence of precise financial data on fertilizer companies and plants, the Contractor developed representative model plant budgets for each of the product segments. Capital costs and operating costs have been estimated for different sizes of plants, based on numerous assumptions concerning such factors as location, age, technology, organization and structure. While wide variations exist among actual operating plants, the model plant data offer helpful insights and provide the most feasible basis for financial analysis.

Using the model plant budgets, detailed cost estimates, based on 1972 prices, have been developed for both direct and indirect expenses for each product segment. These expenses have been computed at utilization rates reflecting 1972 conditions in the industry.

Generally, plant profitability increases with size. Small plants in all categories appear unprofitable under 1972 conditions. Estimated after-tax returns for large plants range from 7 to 15 percent on book investment. Industry-wide, profitability for the basic fertilizer producers rose in 1972 for the third consecutive year, following six years of declining profits (1964-69). The 1972 level--5.9 percent (pre-tax and pre-interest) margin on sales--was approximately half the level of the early 1960's when the industry experienced its highest returns. Over-building in the mid-1960's produced negative margins for most companies in 1968, 1969, and 1970. The cyclical pattern of earnings has been typical of the industry. The industry's return on investment in 1972 has been estimated at 4.3 percent, which was lower than any other industry reported by Fortune magazine in its May, 1973 "Industry Medians" study.

In spite of its relatively weak financial performance, prices were improving in 1972 and pointed to improved margins for the immediate future. Thus, it appears that the larger companies should be able to finance new investment in pollution control facilities where such will be required. Smaller companies with one or two small plants may find new investment difficult or impossible.

III. PRICING

Fertilizer prices have a history of instability. Prices have fluctuated widely in response to supply-demand imbalances, reflecting the competitive nature of the industry and a lack of price leadership. No one producer can be considered dominant on the supply side; buying power is also widely distributed.

Price levels, while fluctuating over shorter time periods, have tended downward from the mid-1950's to 1970, largely as a result of new technologies and larger plants. Since 1970, prices have risen sharply as overcapacity has been absorbed by expanding markets.

The aggregate demand for fertilizers has grown steadily since 1950. Expressed in terms of plants nutrients, consumption in the United States expanded between 1950 and 1972 from one million to eight million short tons of nitrogen (N), from two million to five million short tons of phosphates (P_2O_5) and from one million to over four million short tons of potash (K_2O). Total nutrients consumed as fertilizers rose from four million to over 17 million short tons.

Significant drops in prices occurred as capacity expanded in response to increased demand. Anhydrous ammonia retail price per ton fell from $149 average (1957-59) to $75 in 1970, for the most dramatic decline. Other products fell less percentage-wise, but all products except normal superphosphate experienced price drops, especially during the 1960's.

A major contributing factor to the price decline of the 1960's was the over-building of fertilizer plants. High margins in the early 1960's led to rapid expansion after 1965. Utilization of capacity in the ammonia segment fell from roughly full (100 percent) use to about 73 percent in 1968, while wet phosphoric acid capacity utilization dropped to about 69 percent in 1969. Similar declines occurred in the other product segments. This led to closures of some smaller, older plants.

Foreign markets are important to U. S. fertilizer producers. In 1972, the U. S. exported almost 19 million tons of fertilizer materials, including over 13 million tons of phosphate rock. The products were valued at $339 million. Exports of nitrogen and phosphates amounted to about 17 percent of domestic production in 1972. These exports--consisting chiefly of phosphate rock, ammonia, urea, ammonium phosphates and triple superphosphate--went to more than 50 countries. Chief importers were Canada, Japan, Brazil, Italy, West Germany, and Mexico.

The U. S. also imports considerable amounts of fertilizer materials--8 million tons in 1972. The chief product was potassium chloride (potash) from Canada; the U. S. imported 5 million tons in 1972. The United States was a net exporter of all products except potassium chloride and ammonium nitrate.

IV. IMPACT METHODOLOGY

The fundamental methodology used in the impact analysis is the same as that normally used in capital budgeting studies of new investments. The afore-mentioned model plant budgets provide the basic data for the analysis.

The model plants do not precisely represent any single operation, but they reflect financial and physical characteristics of the industry. Adjustments to model plant budgets to reflect pollution control investment and annual operating costs permit pre-and post-pollution control economic analysis for impacts on prices, profitability and production.

Probable plant closures, a key part of the analysis, are determined through a net present value analysis, by which expected future cash proceeds are discounted at the firm's estimated cost of capital rate. A net present value of less than zero implies that the owner would be better off to liquidate his plant and reinvest the salvage proceeds at the cost of capital rate.

Price increases required to return the plant to pre-pollution control levels of profitability are then calculated to determine expected price effects. An evaluation of ability to pass on required price increases follows.

Finally, broader macroeconomic effects on agricultural production, employment, communities and balance of payments are assessed, using for the most part a qualitative approach.

V. POLLUTION CONTROL COSTS

Investment costs and annual operating expenses for pollution controls were furnished by the Effluent Guidelines Division of EPA. The development of these costs and full descriptions of the technologies appear in the Draft Development Document, separately published by EPA.

The technologies for achieving the effluent limitations guidelines for 1977 (best practical control technology currently available) and for 1983 (best available technology economically achievable) vary somewhat by product and are too complex to permit description in this brief summary.

The estimated costs of water pollution controls by segment are shown in Table 1 for a 1,000 tons per day plant. For larger or smaller plants, there are economies of scale reflected in the nitrogen subcategory but not in the phosphate subcategory, where costs are essentially a function of throughput. Absolute costs are greatest at the BPT level for diammonium phosphate and triple superphosphate. As a percent of selling price, the costs are quite comparable for all products, ranging from 1.3 to 2.8 percent, with TSP having the highest relative BPT cost. At the BAT level, ammonium nitrate has by far the largest investment and annual costs, both absolutely and relatively; annual costs are 3.3 percent of selling price while they are negligible for other products.

The relative impact of the costs will be much greater on smaller plants in all segments, even though absolute dollar costs will be lower. In the DAP and TSP segments, two levels of costs are reported. Some plants currently practice double liming of gypsum pond water and will incur lower costs for additional lime treatment than will those plants with no lime treatment in place.

There is no precise information concerning the number of fertilizer plants with in-place pollution controls. For purposes of analysis, it was assumed that the only in-place technology was double liming in about half of the phosphate segment plants. There are, undoubtedly, some other plants with some degree of pollution controls, since the industry reportedly spent $61 million from 1972-74 for controls; however, detailed information concerning plants by segment is simply not available.

There is one major exception known to exist. Normal superphosphate plants are not expected to incur water pollution control costs and have been excluded from further analysis. The sixty plants are believed to be operating at a no discharge level currently.

New source performance standards for plants coming on line after January 1, 1974, have been established by EPA. In the phosphate subcategory, the standards are the same as BAT; for nitrogen, some effluent guidelines are less stringent for new plants than BAT levels. Since EPA did not furnish costs or technologies for new sources, the Contractor used BPT plus BAT costs for economic analysis. These costs may be overstated somewhat and should provide an upper limit for new source pollution control costs.

Table 1. Estimated incremental investment anda mual operating costs for BPT and BAT effluent controls for 1,000 tons per day model plants (1972 dollars).

	BPT				BAT			
	Invest-	Annual	Annual Costs		Invest-	Annual	Annual Costs	
Product	ment	Costs	$/ton	% Price	ment	Costs	$/ton	% Price
Ammonia	256	264	.84	2.2	104	24	.08	0.2
Ammonium nitrate	290	310	.98	2.2	741	452	1.43	3.3
Urea	405	353	1.12	2.0	158	37	.12	0.2
DAP (0 - 3x)	1,138	572	1.93	2.6	41	10	.03	neg.
(2x - 3x)	762	337	1.13	1.5	41	10	.03	neg.
TSP (0 - 3x)	967	453	1.53	2.8	-	-	-	-
(2x - 3x)	591	217	.73	1.3	-	-	-	-

Note: Annual costs include depreciation and interest. 0 - 3x and 2x - 3x refers to DAP plants with no liming in place and with double liming in place, respectively.

VI. IMPACT ANALYSIS

A. Prices

The future of nitrogeneous fertilizer prices is uncertain, primarily because of the natural gas situation. There are strong indications that natural gas will be in short supply for the next decade and that little expansion will take place in the ammonia industry. Prices of nitrogen products are expected to improve substantially over 1972 levels.

The phosphate subcategory offers a sharply different outlook. New phosphoric acid capacity is expected to come on line in 1974 and 1975, producing downward pressure on prices.

Table 2 shows the estimated prices and capacity utilization rates used in the impact analysis for the various segments from 1973 through 1983, without the effects of pollution controls. Estimated price increases due to pollution controls have been presented in Table 3.

B. Financial Effects

The imposition of pollution controls will decrease the profitability of the smallest ammonia and ammonium nitrate plants, even assuming a price increase. Larger ammonia and urea plants may realize increased profitability, but ammonium nitrate plants all suffer substantially reduced profits after the imposition of BAT controls.

The phosphate subcategory is expected to be in a bad financial position by 1975, due to over capacity. Pollution control costs will depress profits even more. The negative effects will be stronger on the smaller plants and especially on those with no treatment in place.

C. Production Effects

The expected impacts on production are relatively small, except in ammonium nitrate and DAP. Tables 4 and 5 present plant closure estimates, expressed in terms of minimum and maximum expected closures. Table 4 gives numbers of plants, while Table 5 shows tons of annual capacity.

Table 2. Estimated prices and capacity utilization by segment, 1973-1983.

Year	Ammonia 1/ $/ton	Ammonium 1/ nitrate $/ton	Urea 1/ $/ton	DAP $/ton	TSP $/ton	DAP and TSP % Utilization
1973	38	44	57	75	55	95
1974	40	46.5	60	67	47	84
1975	43 2/	49 2/	63 2/	53	37	69
1976				50	35	72
1977				52	37	75
1978				55	39	77
1979				57	40	80
1980				61	43	83
1981				65	46	87
1982				70	49	90
1983				75	53	94

1/ Capacity utilization rate of 90 percent, 1973-83.

2/ 1975 price applies through 1983.

Table 3. Expected price increases due to pollution controls

Segment	Base Price ($/ton)	Percent BPT	Percent BPT + BAT	$/ton BPT	$/ton BPT + BAT
Ammonia	43	3.0	3.5	1.30	1.51
Ammonium nitrate	49	3.5	4.0	1.70	1.96
Urea	63	3.5	4.0	2.20	2.52
DAP 1/	--	---	---	1.45	1.50
TSP 1/	--	---	---	1.05	1.10

1/ Base price and percentages vary by year. The increases amount to 2.0 percent of the estimated 1983 prices of DAP and TSP.

Table 4. Projected plant closures due to pollution controls.

Segment	Range	Base No.	Base Percent	BPT No.	BPT Percent	BPT + BAT No.	BPT + BAT Percent
Ammonia	Minimum	1	1.2	1	1.2	1	1.2
	Maximum	10	12.0	3	3.6	3	3.6
Ammonium nitrate	Minimum	2	3.7	12	22.2	16	29.6
	Maximum	7	13.0	24	44.4	29	53.7
Urea	Minimum	1	2.4	2	4.8	2	4.8
	Maximum	3	7.1	10	23.8	12	28.6
DAP	Minimum	0	0.0	5	12.2	5	12.2
	Maximum	9	22.0	18	43.9	18	43.9
TSP	Minimum	0	0.0	1	6.7	1	6.7
	Maximum	0	0.0	3	20.0	3	20.0

Table 5. Projected capacity of plant closures due to pollution controls (1,000 tons)

Segment	Range	Base No.	Base Precent	BPT No.	BPT Percent	BPT + BAT No.	BPT + BAT Percent
Ammonia	Minimum	178	1.1	55	0.3	55	0.3
	Maximum	241	1.4	118	0.7	118	0.7
Ammonium nitrate	Minimum	38	0.5	828	11.5	1,215	16.9
	Maximum	278	3.9	1,745	24.3	2,427	33.7
Urea	Minimum	55	1.3	85	1.9	85	1.9
	Maximum	110	2.5	372	8.5	466	10.7
DAP	Minimum	0	0.0	345	9.3	345	9.3
	Maximum	316	8.6	1,051	28.6	1,051	28.6
TSP	Minimum	0	0.0	41	2.2	41	2.2
	Maximum	0	0.0	197	10.5	197	10.5

These tables show that small ammonium nitrate plants may be impacted severely, with over half of the plants and about one-third of capacity possibly shut down. Small DAP plants may also suffer severely, with almost half of the plants and just over one-fourth of the capacity affected. Other segments are expected to be impacted much less severely.

New source performance standards may cause some delay in the construction of medium-sized DAP and TSP plants, but expected higher prices in the 1980's would probably make such plants profitable. NSPS will probably not be a deterrent in the other segments.

D. Employment Effects

Total estimated employment decrease due to pollution control ranges from 490 to 1,620 jobs with a payroll loss of $5.9 to $19.4 million. The job losses are potentially highest in ammonium nitrate (850 maximum jobs). Closures are not expected to impact any one area of the country.

E. Community Impacts

The number of jobs and payroll lost in any community is expected to be relatively minor. A single plant closure might mean as many as 40 jobs in a community.

F. Balance of Payments

As a net exporter of fertilizer materials, the U. S. balance of payments could be adversely affected by pollution controls; however, price increases due to pollution controls are relatively small in relation to normal swings in export prices. In the long run, pollution controls should have little effect on foreign trade.

VII. LIMITS TO ANALYSIS

The data used in this analysis have been gathered from government and industry sources. They are believed to be generally accurate, but it must be recognized that variances in local conditions, technologies, and management techniques will cause specific plant operations to vary somewhat from the model plants.

There will be a range of error of ± 5 percent on plant capacities, age and processes and of ± 10 to ± 20 percent on prices, costs, and investment values. Plant closures may vary by ± 35 percent. These ranges of errors would not affect significantly the basic conclusions of the analysis.

Major questions remaining include:

1. Will there be a significant natural gas shortage?
2. Will the projected phosphate capacity actually come on line in the mid-1970's?
3. Will the electrical energy shortage seriously affect the phosphate industry?
4. Will overseas nitrogen and phosphate producers expand significantly and impact U. S. markets?

I. INDUSTRY SEGMENTS

The fertilizer industry includes two broad classifications of products:

SIC 2873 Nitrogenous fertilizers
SIC 2874 Phosphatic fertilizers

This report is limited to the following products: 1/

Nitrogenous fertilizers	Phosphatic fertilizers
Ammonia	Wet-process Phosphoric acid (intermediate)
Ammonium nitrate	Diammonium phosphate
Urea	Triple superphosphate
	Normal superphosphate

A. Types of Firms

1. Size and Number

At the broadest level, firms can be divided into two main groups: basic chemical producers and mixed fertilizer manufacturers. The industry has two other basic functional levels -- raw materials production and retailing (dealers, blenders and/or liquid mixers). This designation parallels the chain of distribution from mine to farm -- wholesale to retail, large scale producing operations (multimillion dollar corporations) to small scale retail operations (companies with $50,000 to $150,000 invested capital). The number of firms in each category is predominately inverse to the unit investment.

1/ Ammonium sulfate and mixed fertilizer manufacturing are included in a Phase II study of the fertilizer industry (EPA 230-1-74-035, September, 1974); superphosphoric acid and defluorinated phosphoric acid are covered in a study of the nonfertilizer phosphate manufacturing industry (EPA 230-1-74-043, September, 1974.

Category	Number of Firms 1/
Raw material miner and refiner	41 2/
Basic chemical producer	109
Mixed fertilizer manufacturer and NSP	150
Blenders and liquid mixers	8,000
Dealers	40,000

1/ Estimated where actual not firm
2/ Excludes natural gas producers and non-captive sulphur operations

The 109 firms engaged in the production of the basic chemicals for fertilizers are dominated by large, integrated, diversified companies, some of which are international in scope. These firms are essentially chemical manufacturers (i.e., Allied Chemical Co., E. I. Dupont de Nemours, Hercules, Inc., Monsanto Co., Borden Chemical Co., Olin Corporation) or petrochemical companies (i.e., American Oil Co., Phillips Petroleum Co., Gulf Oil Co.).

A listing of the dominant firms and their size in relation to the total by product is given below in Section I-A-4.

2. Integration and Diversification

A distinguishing characteristic of these firms is their high degree of diversification. For these companies, fertilizer sales, as a percent of gross sales, may be relatively small. For example, Allied Chemical Co., the largest producer of ammonia, realized only 8 percent of its gross revenues from fertilizer sales in 1971.

Another characteristic of these large producers is their operation of multiple plants with multiple products at a single location. This horizontal integration is reflected in the fact that 84.7 percent of basic product plants are a part of a multiplant complex.

These same companies may be vertically integrated, both backward to raw material production and forward to the manufacture of mixed fertilizers and/or the retail distribution of fertilizers to the farmer-user. Data are not available to identify precisely those firms which are vertically integrated; among the largest basic producers, however, there is widespread backward integration. There is less forward integration into retail distribution than previously, with basic producers now accounting for approximately 25 percent of all retail sales through their own outlets.

The extent to which these integrated, diversified companies dominate the basic production segment of the industry is partially obscured by the fact that many smaller but important producing companies are operating subsidiaries of the larger companies. In many instances, the operating company has retained its corporate name, even though it has been integrated with the parent company from an operations viewpoint. This is an important consideration in evaluating the impact of increased costs resulting from pollution abatement. Whether or not a given plant may close as a result of increased costs will depend in many cases on the role of that plant in the total corporate strategy.

In addition to the large, integrated, diversified companies, there are three other types of firms engaged in basic production of fertilizer chemicals. These are (1) the cooperatives, which are also generally integrated and diversified; (2) the smaller chemical companies which have one or two locations and produce only one or two products; and (3) manufacturers of unrelated products (i.e., steel) who have by-product chemicals which move into fertilizer production. These groups account for a relatively small amount of total capacity.

Most descriptions of the industry have been either product-oriented or organization-oriented. Figure I-1 attempts to combine these two orientations to give an overview of the industry. The inter-relationships among elements are numerous and the extent to which integration is possible is even greater.

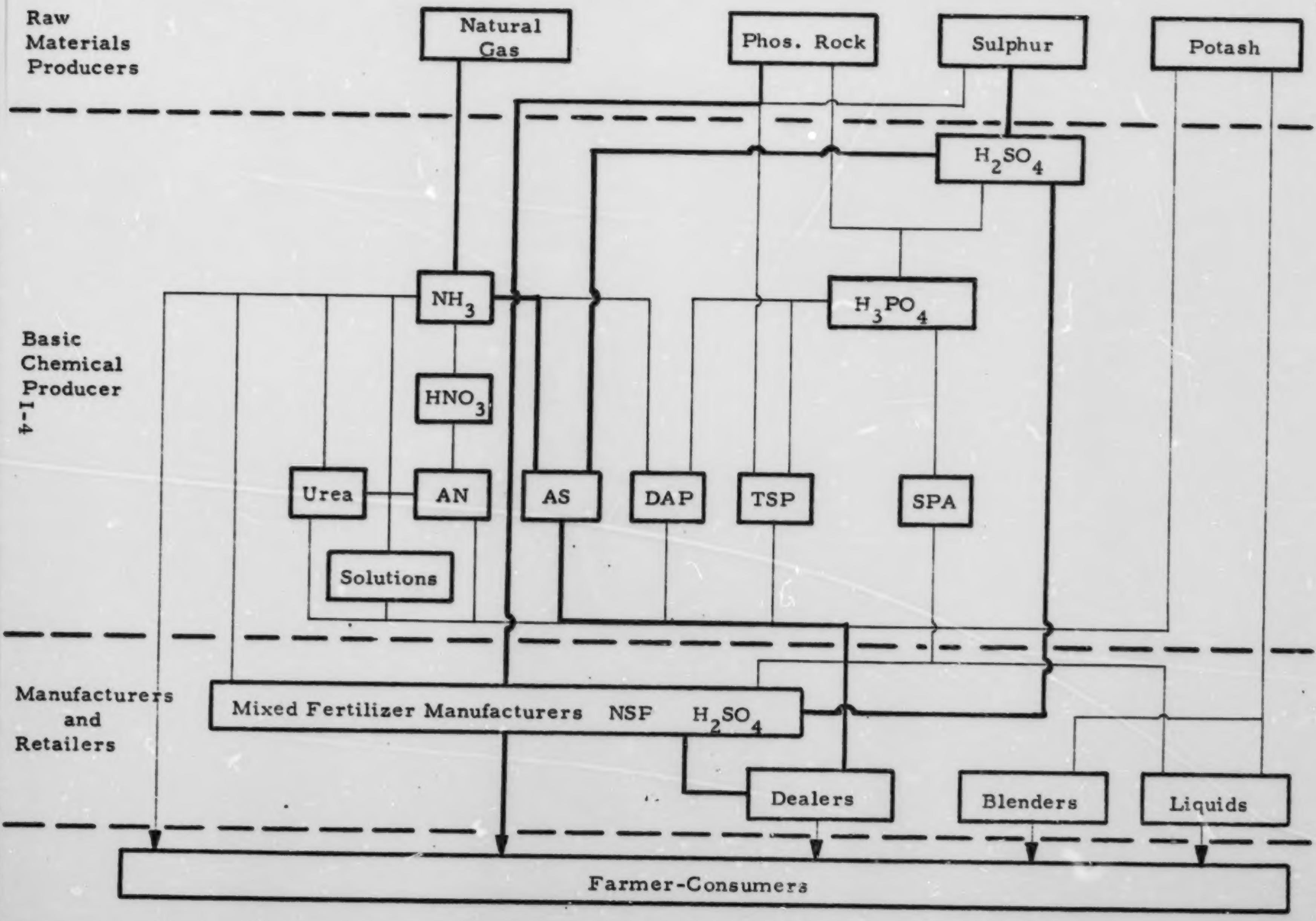
However, from the possibilities shown, there are two general areas of stratification which may be discerned. One is specialization by product -- nitrogenous, phosphatic or potassic fertilizer. The other is by function -- raw materials miner and refiner, basic chemicals producer, mixed fetilizer manufacturer and retailer (dealer, blender and/or liquid mixer).

3. Products

The fertilizer industry has a number of different products, although most are a matter of changes in degree. The industry is based on three basic nutrients -- nitrogen, phosphate and potash.

This study addresses itself only to certain producers of nitrogen and phosphates. Included in these categories are the following products:

Figure I-1. Fertilizer Industry Perspective - Product/Function Specializations


Raw Materials Producers
Natural Gas
Phos. Rock
Sulphur
Potash
H_2SO_4
Basic Chemical Producer
NH_3
H_3PO_4
HNO_3
Urea
AN
AS
DAP
TSP
SPA
Solutions
Manufacturers and Retailers
Mixed Fertilizer Manufacturers NSF H_2SO_4
Dealers
Blenders
Liquids
Farmer-Consumers

Ammonia
Ammonium nitrate
Urea
Phosphoric acid (intermediate)
Normal superphosphate
Diammonium phosphate
Triple superphosphate

Nitric acid and sulphuric acid, intermediate products, are outside the scope of this analysis, except as the costs of these intermediates affect the manufacture of some of the above listed products.

4. Number of Plants by Ownership and Capacity

Through industry sources, DPRA has identified 109 basic chemical firms plus 9 non-basic producers of NSP as owners of 327 plants. The number of firms and plants are shown below:

	No. of Firms	No. of Plants
Ammonia	57	83
Ammonium nitrate	36	54
Urea	35	42
Phosphoric acid	26	32
Normal superphosphate	27	60
Ammonium phosphate	32	41
Concentrated superphosphate	13	15
	--	327

Ammonia

Within the ammonia segment of the fertilizer industry, the following companies (one or more plants) are the major producers:

Ten Largest Firms	Annual Capacity (1,000 tons)	No. of Plants
Allied Chemical Corporation	962	4
C. F. Industries	863	3
E. I. Dupont de Nemours	780	3
Collier Carbon and Chemical Co.	770	2
Chevron Chemical Co.	745	3
American Oil Co.	720	1

Ten Largest Firms	Annual Capacity (1,000 tons)	No. of Plants
Agrico Chemical Co.	680	2
Phillips Petroleum Co.	650	3
U.S.S. Agri-Chem. Co.	647	3
Farmland Industries	560	3
	7,377	27
Total of firms in industry 57	16,888	
Percent of total capacity of 10 largest firms	44%	
Percent of total plants (27/83)	33%	

Of the above, C. F. Industries and Farmland Industries are farmer cooperatives and oriented to agriculture and fertilizers. The others are recognizable as large multi-product corporations.

Ammonium nitrate

Since most ammonium nitrate facilities are integrated with ammonia and nitric acid, scale of operation of the intermediates is critical. Most ammonium nitrate production facilities are somewhat aged and tied into small scale ammonia production units.

The following companies are the top ten producers:

Ten Largest Firms	Annual Capacity (1,000 tons)	No. of Plants
Hercules, Inc.	677	3
Monsanto Co.	625	2
Allied Chemical Co.	497	3
Kaiser Agricultural	396	4
Gulf Oil Corporation	360	1
Farmers Chemical Co.	330	2
Mississippi Chemical Corp.	330	1
USS Agri-Chem. Co.	282	3
Atlas Chemical Co.	273	2
Cooperative Farm Chem. Assn.	270	1
	4,040	22
Total of firms in industry 36	7,192	
Percent of total capacity of 10 largest firms	56%	
Percent of total plants (22/54)	41%	

Of the above, Hercules and Atlas production is predominantly industrial. Monsanto's split is unknown.

Urea

Among the top ten producers are the following companies:

Ten Largest Firms	Annual Capacity (1,000 tons)	No. of Plants
Allied Chemical Co.	455	3
Triad Chemical Co.	420	1
Collier Carbon and Chem. Co.	405	2
Vistron Corp.	238	1
Farmer's Chemical Assoc.	210	2
Agrico Chem. Co. (Willchemco)	200	1
Valley Nitrogen Products Inc.	190	2
Nipak, Inc.	186	2
Borden Chemical Co.	165	1
Olin Corp.	160	1
	2,629	16
Total of firms in industry 35	4,363	
Percent of total capacity of 10 largest firms	60%	
Percent of total plants (16/42)	38%	

Possibly only Farmers Chemical Association, Valley Nitrogen and Nipak of the listed companies are predominantly fertilizer oriented. There appears to be sufficient spread between costs due to economies of scale that several small sized producers will be sensitive to any increased costs due to pollution abatement.

Phosphoric Acid

The phosphoric acid segment is dominated by the ten largest firms as shown below:

Ten Largest Firms	Annual Capacity (1,000 tons P_2O_5)	No. of Plants
C. F. Industries	880	3
Freeport Minerals Co.	750	1
Gardinier	544	1
Farmland Industries	455	1
Beker Corp.	411	3
Texas Gulf Sulphur Corp.	346	1
Olin Corporation	337	2
W. R. Grace & Co.	315	1
USS Agri-Chemicals, Inc.	266	2
Occidental Chemical Co.	247	2
	4,551	17
Total of firms in industry 26	6,370	
Percent of total capacity of 10 largest firms	71%	
Percent of total plants (17/32)	53%	

The industry is concentrated in Florida adjacent to phosphate rock operations. Several new large facilities are under construction.

Normal superphosphate

Normal superphosphate (NSP) is produced by 27 firms. The eleven largest, in terms of NSP capacity, are as follows:

Eleven Largest Firms	Annual Capacity (1,000 tons P_2O_5)	No. of Plants
Esmark (Swift & Co.)	124	7
Agrico Chem. Co. (Will Chem. Co.)	72	8
U.S.S. Agri-Chemicals, Inc.	68	6
International Minerals	66	5
W. R. Grace	60	4
Kerr-McGee	44	3
Texaco (Federal Chem.)	44	4
Borden Chemical Co.	30	2
Gold Kist	29	2
Gardinier	22	1
Kaiser Agri. Chem.	22	1
	581	43
Total of firms in industry 27	735	
Percent of total capacity of 11 largest firms	79%	
Percent of total plants (43/60)	72%	

Ammonium phosphate

Of the 41 plants, only two are of the large-sized variety -- 300,000 tons per year or over. However, several new large-sized plants are presently under construction. Sixteen plants are less than 50,000 tons annual capacity. Ten are from 50,000 tons to 99,000 tons.

Of the 32 companies producing ammonium phosphates, the following are among the top ten:

Ten Largest Firms	Annual Capacity (1000 tons P_2O_5)	No. of Plants
C. F. Industries	450	1
Beker Ind. Corp.	432	3
Agrico Chem. Co. (Willchemco)	300	1
Brewster Phosphates	200	2
Olin Corporation	198	1
Farmland Industries	184	2
Arco Chemical	170	1
Gardinier	170	1
Mississippi Chem. Corp.	153	1
Allied Chemical Corp. (liquid)	135	1
	2,392	14
Total of firms in industry 32	3,681	
Percent of total capacity of 10 largest firms	65%	
Percent of total plants (14/41)	34%	

Virtually all ammonium phosphates are used as fertilizer. However, several multi-line corporations are among the producers. The industry is largely concentrated in Florida, adjacent to phosphate rock mining operations.

Triple superphosphate

The producers of triple superphosphate and their respective capacities are:

Firms	Annual Capacity (1000 tons P_2O_5)	No. of Plants
Gardinier	375	1
W. R. Grace & Co.	365	2
C. F. Industries	209	2
Agrico Chem. Co. (Willchemco.)	165	1
Texas Gulf Sulphur Co.	164	1
Royster Co.	123	1
U.S.S. Agri-Chemical Co.	121	1
J. R. Simplot Co.	89	1
Occidental Chemical Co.	78	1
Mississippi Chem. Corp.	73	1
Farmland Industries	46	1
Stauffer Chemical Co.	41	1
Borden Chemical Co.	33	1
Total industry	1,882	15

There are thirteen companies currently producing TPS. The industry is concentrated in Florida adjacent to phosphate rock mining operations.

B. Types of Plants

This section outlines the type of plants analyzed in the survey. Emphasis is directed to size, age, location, technology, efficiency, and stage in the production process. For nitrogen fertilizers, ammonia is the basic building block. For phosphate fertilizers, phosphoric acid is the basic building block. The reader is referred back to Figure I-1 to review the interrelationships among these products and to recall their various flow positions in the production process.

The discussion and tables which follow are based on plant lists supplied by TVA and industry sources. Some of the data may be subject to question because of plant closures which have gone unreported or because of other unknown causes. In other words, the plant lists are somewhat tentative in nature but reflect the best available data.

1. Size

Even within product components, there is considerable range between size of plants in terms of annual capacities. These are summarized for the basic chemical products as follows:

Product	No. of Plants	Total Capacity
Ammonia		
0 - 99 (000 tons)	21	1,087
100 - 199	24	3,249
200 - 299	16	3,522
300 - 449	15	5,160
450 (over)	7	3,870
	83	16,888
Ammonium nitrate		1,790
0 - 99 (000 tons)	27	1,790
100 - 149	11	1,378
150 - 249	9	1,689
250 - (over)	7	2,335
	54	7,192
Urea		
0 - 99 (000 tons)	26	1,444
100 - 149	7	836
150 - 249	7	1,313
250 (over)	2	770
	42	4,363
Phosphoric acid		
0 - 74 (000 tons P_2O_5)	7	221
75 - 149	7	781
150 - 249	11	2,078
250 (over)	7	3,290
	32	6,370

	No. of Plants	Total Capacity (000 tons)
Normal superphosphate		
0 - 8 (000 tons P_2O_5)	16	93
9 - 12	16	166
13 - 16	17	251
17 (over)	11	225
	60	735
Ammonium phosphate		
0 - 49 (000 tons P_2O_5)	16	360
50 - 99	10	698
100 - 199	13	1,873
200 (over)	2	750
	41	3,681
Triple superphosphate		
0 - 99 (000 tons P_2O_5)	8	430
100 - 199	5	757
200 (over)	2	695
	15	1,882

Ammonia - Of the 83 ammonia plants, 21 or about one-quarter of the total number are less than 100,000 tons annual capacity and account for only 6 percent of total annual capacity. Twenty-one of these plants are of the large and super large variety - 300,000 tons per year up to 720,000 tons per year. In the larger plant category, 7 plants or only 8 percent of the total number account for 23 percent of total annual capacity.

Ammonium nitrate - A review of the distribution of ammonium nitrate plants reveals that about one-half of them are on the small side (less than 100,000 tons capacity). Ammonium nitrate production can claim only standard technology--efficiencies being inherent only in larger scale of operation.

Urea - A review of the size of urea plants reveals that two of the 42 plants are of an extremely large variety. The majority of the plants are small (less than 100,000 tons capacity). There is nothing distinctive either in technology of urea production or process. Only economies of scale of operations appear to differentiate between plants.

Phosphoric acid - Seven plants out of 32 account for over one-half of total production. Economies of scale parallel that of the other producing plants in the fertilizer industry.

Normal superphosphate - Fifty-seven of the 60 NSP plants are a part of mixed fertilizer manufacturing complexes; only three plants operate on a stand-alone basis. NSP plants are relatively small in size -- the largest having an annual capacity of 25,000 tons of P_2O_5 or larger. Thirty-two plants are 12,000 tons of P_2O_5 or less.

Ammonium phosphate - Almost all of the plants in this product group are of the conventional type -- neutralization of phosphoric acid with ammonia. However, a large number of plants are in the small size category -- perhaps more than any other product group. The nitric phosphate process is less well known. Two small plants have been identified. The 21-53-0 plant, in all respects, is of the conventional type except that thermal acid has been substituted for wet-process acid.

Triple superphosphate - Only 13 plants are included in this group. The product has almost been made obsolete by DAP, but it still has specific demand for non-nitrogenous fertilizer grades.

2. Age

The fertilizer industry is a relatively young industry in comparison to basic industries such as steel. As shown below, only 20 percent of the plants are pre-1960 vintage. Nitrogen plants tend to be older with about half 1965 vintage and older. The phosphate industry has only 10 to 15 percent of its plants pre-1965. A summary of the estimated age of plants is shown below by product.

Product	No. Plants by Year Built				
	Pre-1960	1960-1965	1966-1972	Unknown 1/	Totals
Ammonia					
No. plants	21	27	32	3	83
Capacity (000 tons)	3,170	4,563	8,815	340	16,888
Ammonia nitrate					
No. plants	20	20	13	1	54
Capacity (000 tons)	3,350	2,162	1,600	80	7,192
Urea					
No. plants	8	10	24	0	42
Capacity (000 tons)	848	608	2,907	0	4,363
Phosphoric acid					
No. plants	3	3	16	10	32
Capacity (000 tons P_2O_5)	234	215	3,507	2,414	6,370
Normal superphosphate					
No. plants	0	0	0	60	60
Capacity (000 tons P_2O_5)	0	0	0	735	735
Ammonium phosphate					
No. plants	1	3	16	21	41
Capacity (000 tons P_2O_5)	17	105	1,818	1,741	3,681
Triple superphosphate					
No. plants	1	1	7	6	15
Capacity (000 tons P_2O_5)	33	121	1,057	671	1,882
Total					
No. plants	54	64	108	101	327

1/ Most plants believed to be pre 1960 vintage.

3. Location

The location of the phosphate segment is now largely raw material oriented, while the nitrogen segment is both raw material and market oriented. The manufactured goods component is primarily market oriented. A detailed discussion of location follows.

The raw materials necessary for the production of the basic fertilizer compounds are:

Product	Raw Material
Ammonia	Air, natural gas
Ammonium Nitrate	Ammonia, nitric acid
Urea	Ammonia, carbon dioxide
Phosphoric Acid	Phosphate rock, sulfuric acid
Normal Superphosphate	Phosphate rock, sulfuric acid
Diammonium Phosphate	Ammonia, phosphoric acid
Triple Superphosphate	Phosphate rock, phosphoric acid
Intermediates	
Nitric Acid	Ammonia, air
Sulfuric Acid	Sulfur

The strategic raw materials necessary for both fertilizer products and intermediates are:

Natural Gas
Sulfur
Phosphate Rock

The major source of natural gas in the United States is along the Texas-Louisiana Gulf Coast. About 50 percent of the ammonia plants, especially the newer ones, are located in this area. Ammonia contains 82 percent nitrogen and can be transported at relatively low cost. The West North Central States is another area of heavy concentration of ammonia plants. These are market oriented locations and their natural gas requirements are brought in by pipeline from Texas and Louisiana.

Sulfur largely comes from brimstone deposits although large quantities are also recovered from sour natural gas and refinery gases. Brimstone deposits are located along the Texas - Louisiana Gulf Coast. Sour gas is also incidental to this area; however, Canada (Alberta) has been an increasingly major source of sulfur from sour gas. The Gulf Coast sulfur is readily transported by water.

The major economic deposits of phosphate rock are in central Florida, about 50 miles east of Tampa. Some new deposits are being mined in North Florida about 50 miles west of Jacksonville and in North Carolina on the coast. Tennessee has some minor deposits, but theyare low grade and used for electric furnace phosphorus production. The Western States have some major deposits but account for only a minority of phosphate fertilizer production. Consequently, phosphoric acid plants are concentrated in Florida adjacent to the rock mines.

The other raw materials -- air (nitrogen source) and carbon dioxide (by-product from NH_3 manufacture) -- are readily available.

There are 327 plants producing basic fertilizer materials and normal-superphosphate, excluding nitric acid and sulphuric acid plants. When NA and SA plants operated in conjunction with other basic products plants are added, there are 406 plants.

Tables I-1 and I-2 show the regional distribution of plants and capacities by product. Figures I-2 through I-8 show the plant locations.

Table I-1. Distribution of plants by product and geographic region, 1972

Product	New England	Middle Atlantic	South Atlantic	North Central East	North Central West	South Central East	South Central West	Mountain	Pacific	Alaska, Hawaii, Puerto Rico	Total
	Number of Plants										
Ammonia	0	7	6	4	15	7	29	4	10	1	83
Ammonium nitrate	0	3	9	4	14	3	10	3	8	0	54
Urea	0	3	4	2	8	5	12	1	6	1	42
Wet phosphoric acid	0	0	13	3	1	1	6	4	4	0	32
Normal superphosphate	0	4	31	7	2	9	4	1	2	0	60
Triple superphosphate	0	0	11	0	1	1	0	2	0	0	15
Ammonium phosphate	0	0	10	3	4	3	9	5	7	0	41

Source: Developed by DPRA from industry lists published by Tennessee Valley Authority, industry contacts and own files. All subsequent plant and capacity tables are from this same source. See footnote on Page VII-49 concerning the nature of the plant lists.

Table I-2. Distribution of capacity by product and geographic region, 1972

Product	New England	Middle Atlantic	South Atlantic	North Central		South Central		Mountain	Pacific	Alaska Hawaii, Puerto Rico	Total
				East	West	East	West				
	1,000 Tons										
Ammonia 1/	0	1,067	1,042	955	2,417	1,786	7,587	306	1,218	510	16,888
Ammonium nitrate 1/	0	246	1,188	402	2,358	585	1,695	241	477	0	7,192
Urea 1/	0	190	298	338	620	361	1,773	50	383	350	4,363
Wet phosphoric acid 2/	0	0	3,736	356	190	160	1,427	412	89	0	6,370
Normal superphosphate 2/	0	50	379	95	27	121	35	3	25	0	735
Triple superphosphate 2/	0	0	1,634	0	45	73	0	130	0	0	1,882
Ammonium phosphate 2/	0	0	1,222	222	353	248	1,150	356	130	0	3,681

1/ Product
2/ 100 percent P_2O_5

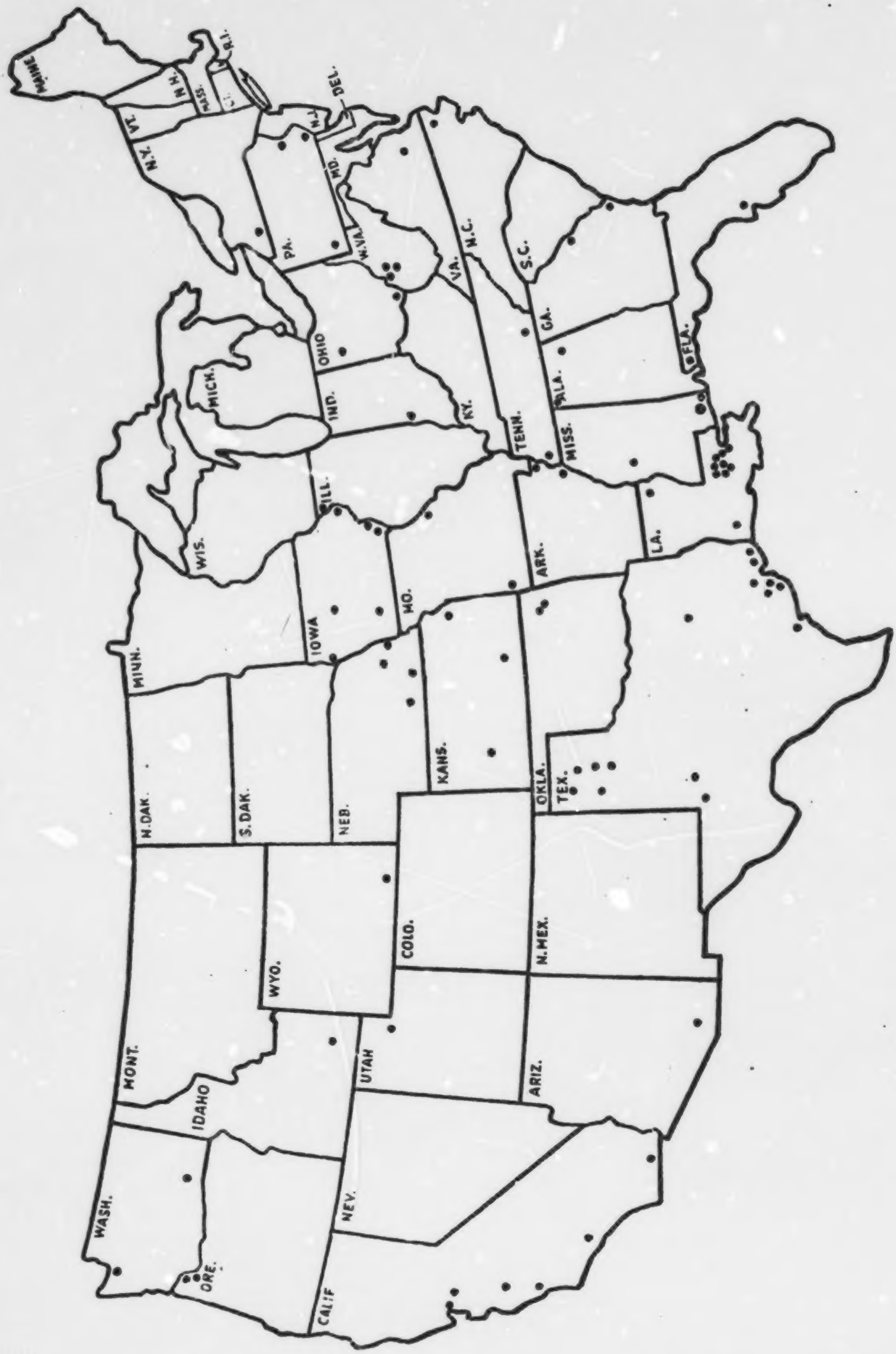

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Figure I-2. Location of ammonia plants.

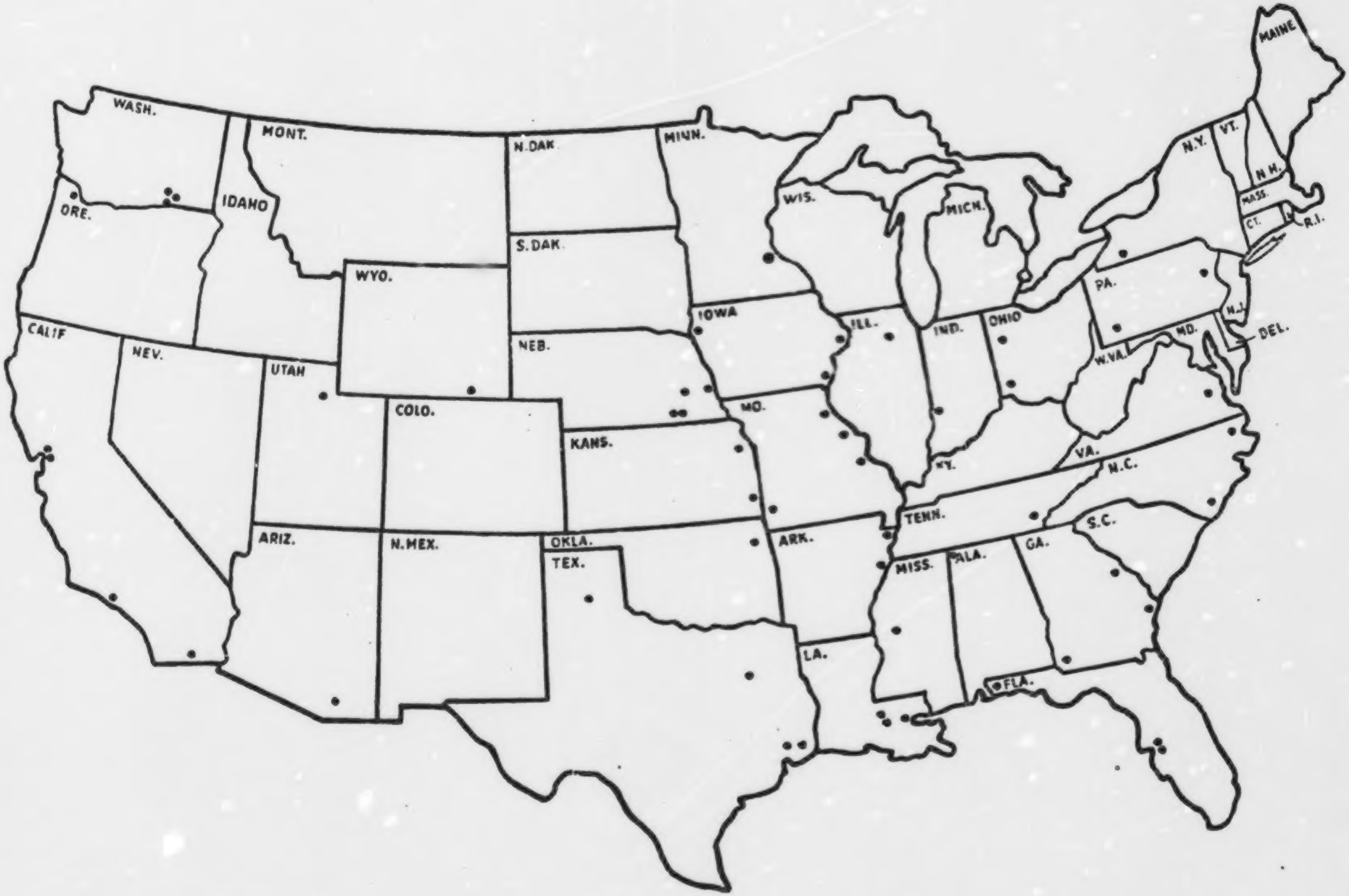
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Figure I-3. Location of ammonium nitrate plants.

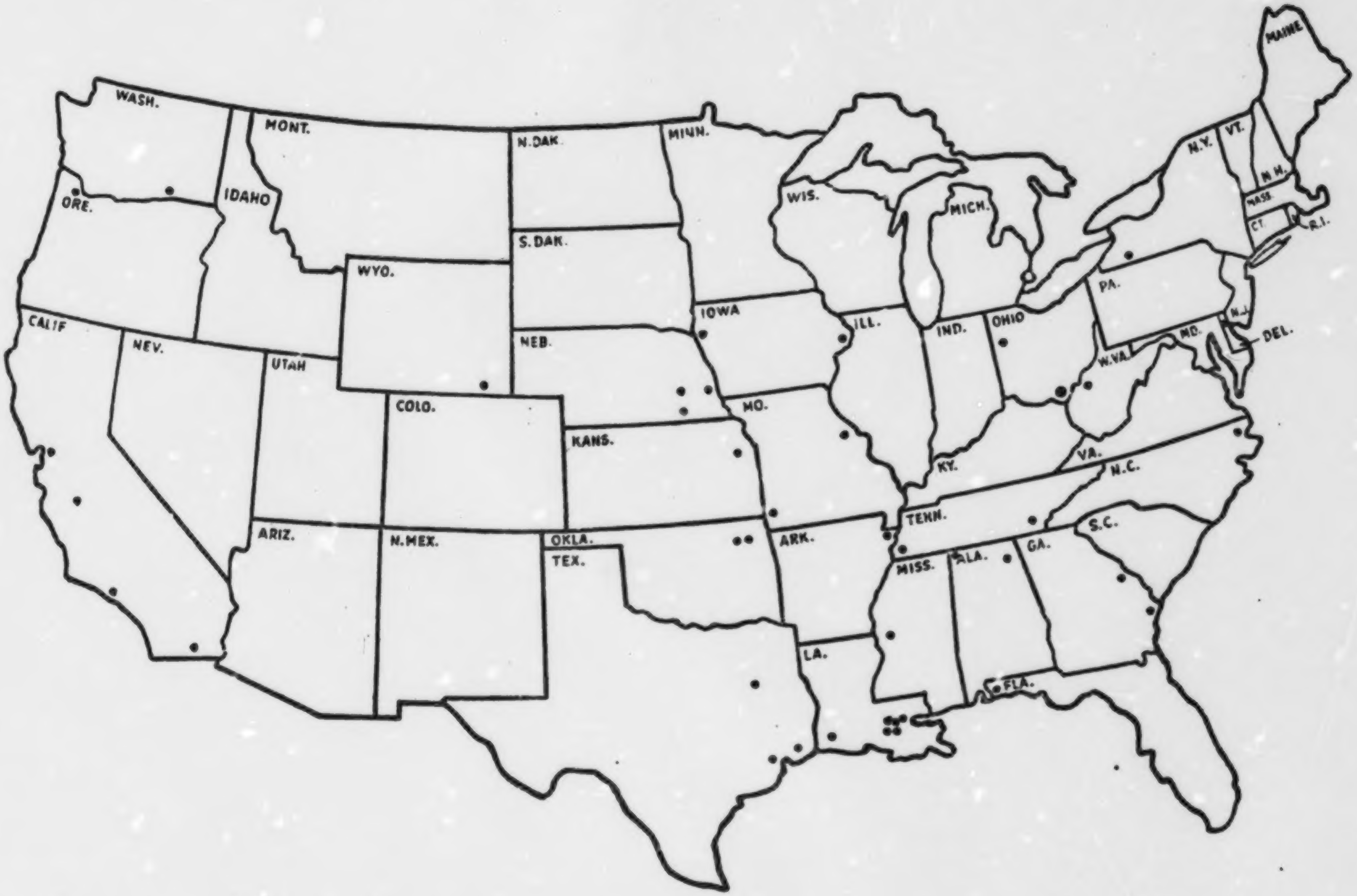
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Figure I-4 Location of urea plants.

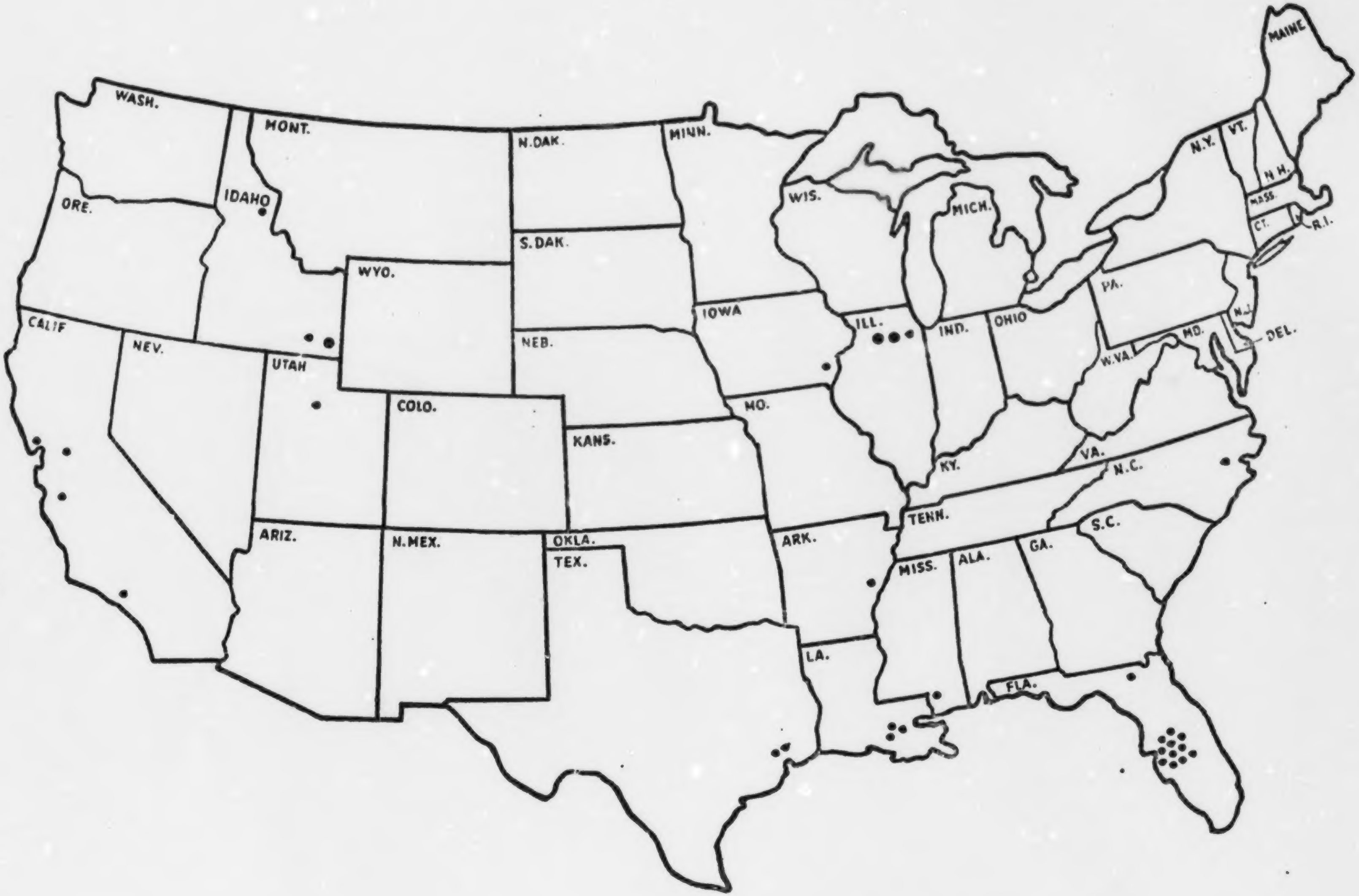
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Figure I-5. Location of wet-process phosphoric acid plants.

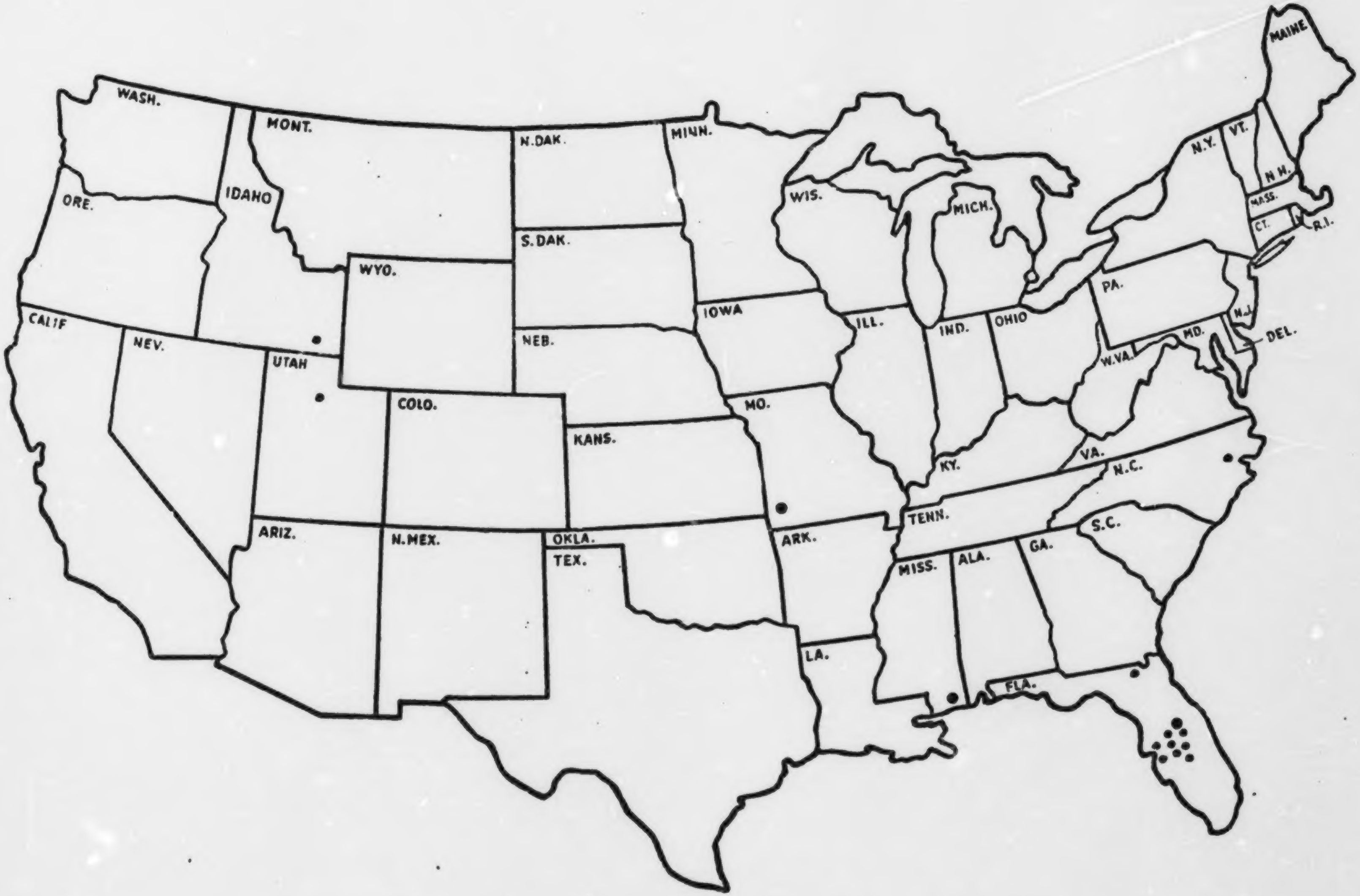
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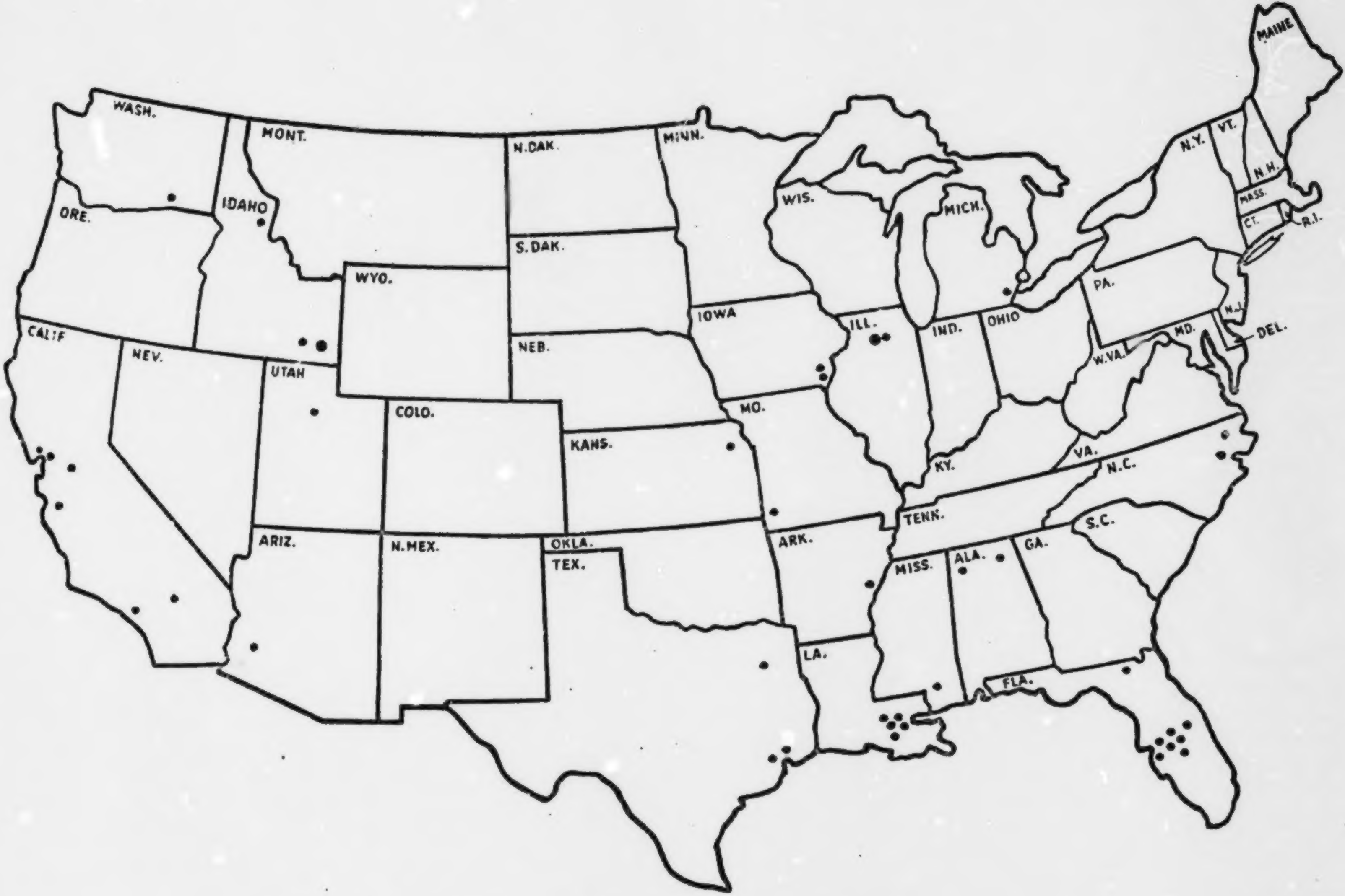
Figure I-6. Location of concentrated superphosphate plants.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R.I.

Figure I-7. Location of ammonium phosphate plants.

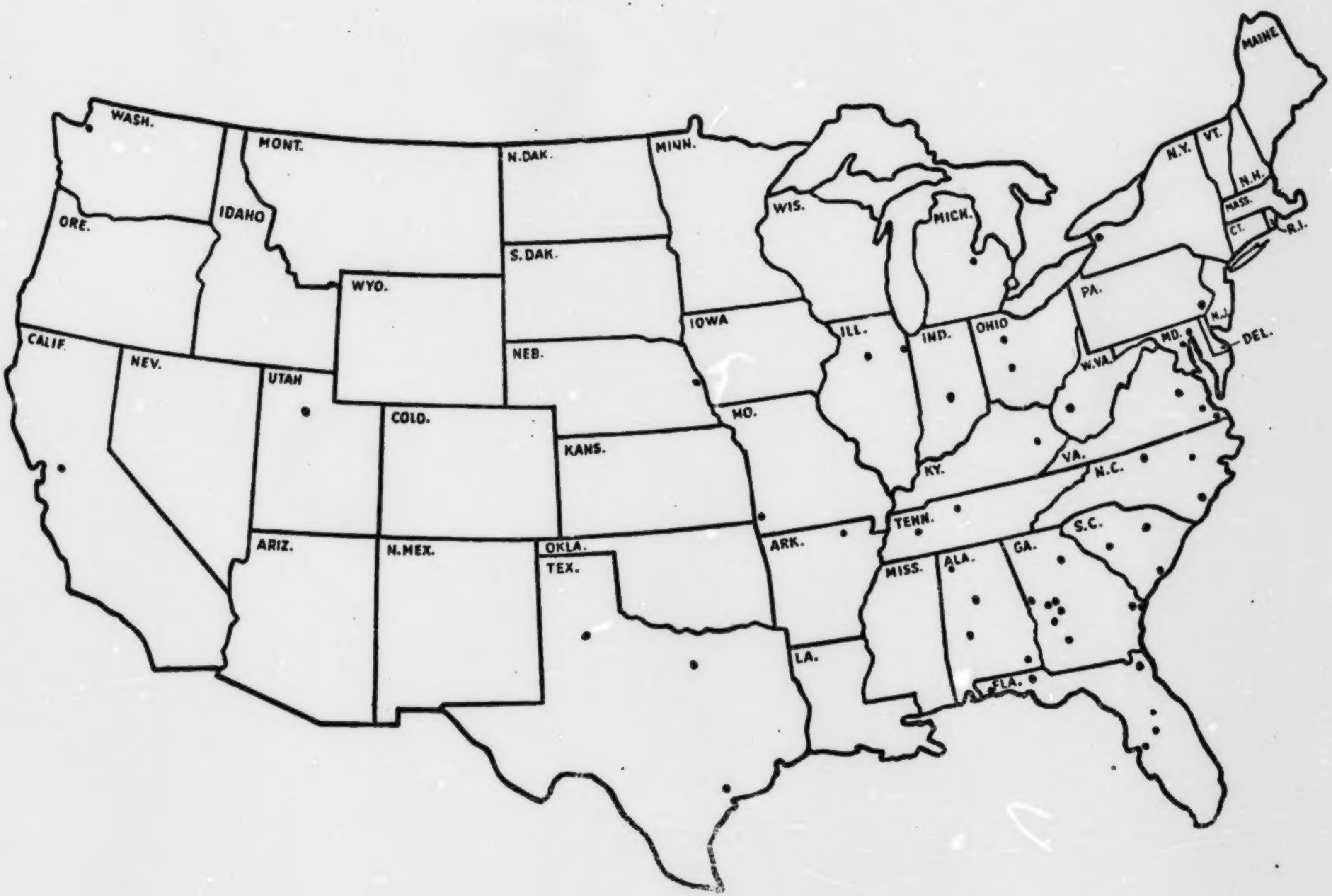
WASH.
MONT.
N.DAK.
MINN.
ORE.
IDAHO
WIS.
MICH.
N.Y.
VT.
N.H.
MAINE
MASS.
CT.
R.I.
S.DAK.
WYO.
IOWA
PA.
N.J.
DEL.
MD.
CALIF.
NEV.
UTAH
NEB.
ILL.
IND.
OHIO
W.VA.
COLO.
MO.
KANS.
VA.
KY.
N.C.
TENN.
S.C.
ARIZ.
N.MEX.
OKLA.
TEX.
ARK.
MISS.
ALA.
GA.
LA.
FLA.

Figure I-8. Location of normal superphosphate plants.

4. Technology and efficiency

The basic chemicals segments of the industry can be characterized as high technology, involving continuous chemical processes. In terms of assets per employee, the fertilizer industry ranks third as a group with $80,200 per employee. It follows the petroleum industry with $113,600 per employee and mining with $83,900 per employee. The manufactured goods segment is characterized with a much lower level of technology reflecting the much simpler batch type operations.

In labor productivity terms, as indicated by the above data, the fertilizer industry is very efficient. This fact is also borne out by sales per employee. The fertilizer industry has $62,400 sales per employee compared to the chemical industry as a whole with $35,900 per employee.

As with most process products, variations in the method of process can be found. The processes discussed are those commonly discussed in the industry in lay terms. For further discussions and detailed descriptions of processes the reader is referred to:

Wellman Lord, Inc., Draft Copy, Study Report, Industrial Waste Studies Program, Group 6, Fertilizers, EPA, PN 3776, July 1971.

Battelle Memorial Institute, Inorganic Fertilizer and Phosphate Mining Industries, Water Pollution and Control, EPA, 12020 FPD 09/71, Sept. 1971.

The basic processes used in basic fertilizer manufacturing are described below.

Ammonia - Steam Reforming, Natural Gas, Reciprocal Compressor. About 43.4 percent of all synthetic ammonia produced in the United States is produced in plants using the Natural Gas - Steam Reforming process with multi-cylinder reciprocating compressors. Hydrogen and nitrogen required for synthesis of ammonia is obtained from natural gas, steam and air. The gas is compressed in reciprocating compressors driven by either electric motors or gas engines to 5000 psig in four stages to reach reaction pressure. These plants are small (less than 600 tons per day), old (built before 1965) and have high operating costs per ton of ammonia.

Ammonia - Steam Reforming, Natural Gas, Centrifugal Compressor. About 51.5 percent of all synthetic ammonia produced in the United States is produced in plants using the Natural Gas - Steam Reforming process with centrifugal compressors using single steam turbine drivers. Hydrogen and nitrogen required for ammonia synthesis is obtained from natural gas, steam and air. The centrifugal compressor is used to bring synthesis and recycle gas up to reaction pressures. These plants are large (more than 600 tons per day), new (built after 1965) and efficient (low operating costs).

Ammonia - Electrolytic Hydrogen. Only 1.6 percent of the synthetic ammonia produced in the United States is produced from electrolytic hydrogen. Compressed air and hydrogen are burned in a combustion furnace to produce a hydrogen-nitrogen mixture with a three-to-one ratio. The gas passes through the compression and synthesis section as in other processes. These plants are small and operated in conjunction with chlorine manufacture where the source of hydrogen is from chlorine cells.

Ammonia - Pollutants. About 3.5 percent of the synthetic ammonia produced in the United States is produced from coke oven gas and refinery tail gases. Coke oven gas has or is being phased out. Refinery tail gases are reformed as with natural gas. These plants are operated in conjunction with refinery complexes.

Ammonium Nitrate - Prill. Almost all solid ammonium nitrate produced in the United States is produced in plants with a prilling tower whereby an ammonia nitrate melt is dropped as a spray through a counter current of air. The only other process (Stengel) is used at one identifiable plant whereby the ammonium nitrate melt is spread out to solidify on a water cooled stainless steel belt and then broken into flakes. Nitric acid and ammonia, usually produced in an adjacent integrated complex, are the raw material feed stocks for ammonium nitrate production.

Urea - Total Recycle. Urea is produced by dehydration of ammonium carbamate synthesized from ammonia and carbon dioxide. Ammonia and carbon dioxide are obtained from adjacent ammonia plants where carbon dioxide is a by-product made during the preparation of synthesis gas for ammonia production. In the reactions about 60 percent of the ammonia is converted to urea per pass. In the total recycle process, all of the off-gases are recycled to produce urea. Ammonia conversion is thus almost one hundred percent. The large, newer plants producing solid urea use the total recycle process.

Urea - Partial Recycle. Portion of off-gases are reused for urea production.

Urea - Once Through. Off-gases are not recycled and must be used elsewhere. This process is usually used to produce relatively small quantities of urea for use in urea - ammonium nitrate solutions only.

Wet Process Phosphoric Acid. Phosphate rock is reacted with sulphuric acid to produce phosphoric acid and calcium sulphate (gypsum). The gypsum is insoluble and can be mechanically separated from the weak phosphoric acid (41% H_3PO_4). This is normally accomplished on a horizontal rotating pan type filter. Process conditions cause fluorine to be evolved which is recovered by water scrubbing collected gas and transferring fluorine to a waste water stream. Also, approximately 5 tons of gypsum per ton of P_2O_5 produced must be sluiced to a holding area (gyp pond). Scale of operation is the distinguishing feature between most Wet P_2O_5 plants. Wet acid is usually produced in conjunction with an adjacent integrated sulphuric acid plant.

Normal Superphosphate. The NSP process is essentially low technology. Manufacturing is achieved by mixing finely ground phosphate rock (68-76% BPL) with sulfuric acid. The ratio of acid to rock varies from 55 to 65 pounds of sulfuric acid (100 percent basis) per 100 pounds of rock. Older plants are batch-type with separate pan mixers and reaction chambers (or dens). Newer installations are continuous process mills which permit hourly production up to 100 tons with much greater efficiency. The product is sold in pulverized run-of-pile form or may be granulated for direct application or for bulk blending. Pulverized NSP goes primarily to ammoniation-granulation plants. Formerly, NSP producers generally had captive sulfuric acid, but now the majority of plants purchase their acid. A by-product of NSP production is fluorine which creates a pollution problem. Twenty-two of the 60 NSP plants now have recovery processes for fluosilicic acid and sodium silicofluoride by-products which can be sold for water treatment. Compared to the manufacture of triple superphosphate and ammonium phosphates, the NSP process is economically inefficient.

Concentrated P_2O_5. Triple superphosphate is produced in a conventional granulation unit. High grade phosphate rock is acidulated with sufficient phosphoric acid to convert insoluble tri-calcium phosphate to soluble monocalcium phosphate forms. The run-of-pile product can flow directly to a granulation dryer for granulation.

Ammonium Phosphate - Conventional. The TVA process is most popular in recently built plants. Weak phosphoric acid is partially neutralized by anhydrous ammonia. Temperature is maintained at about 240° F by adjusting the acid dilution so that water evaporation balances the heat of reaction. After the initial neutralization step, the slurry formed and recycling material are fed into a rotating drum where final ammoniation and granulation occur. About 97 percent of all ammonium phosphate produced in the United States is produced in plants utilizing the conventional methods.

Ammonium Phosphate - Nitric. Phosphate rock is acidulated with nitric acid and uaually some small quantities of phosphoric acid to produce low analysis grades of N-P mixtures. Only two plants have been identified in the United States.

Ammonium Phosphate - 21 - 53 - 0. This is similar to the conventional process, except that higher analysis furnace phosphoric acid is employed as the internal rate raw material instead of wet-process phosphoric acid. Only two plants have been identified in the United States and their production is negligible.

5. Size - age - Process relationships

Tables I-3 to I-9 summarize the distribution of plants in each product category by size-age-process. In general, the small plants are older. Also, production in the various segments tends to concentrate primarily in one process, even though several processes are in use.

6. Integration

DPRA has identified 44 present plant combinations in which the companies within today's basic fertilizer materials industry are engaged. These range from single unit operations of either anhydrous ammonia, ammonium nitrate, urea, wet acid, ammonium phosphate or ammonium sulfate up to integrated fertilizer complexes with seven plants at a single location. Single plant nitric and sulphuric acid units have been excluded from these groupings since they cannot be related to any basic fertilizer material operation. Numbers of plants and owners are summarized in Table I-10. There are 393 plant operations at 166 company locations producing the 44 product combinations. Of these, 60 company locations have single unit operations and account for 15.3 percent of the total number of plants. Another 103 company locations, or 62.1 percent of all locations have two to five plants at each location and account for 313 plant operations or 79.7 percent of the total. These seem to be the typical operation. Table I-11 presents the detailed breakdown of number of companies and number of plants per location for each of the 44 product combinations.

Table I-3. Ammonia: Number and capacity of plants by age and capacity range (1,000 tons)

Process and age group	0 - 99		100 - 199		200 - 299		300 - 450		450 ---		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Steam reforming natural gas												
Pre-1960 1/	4	265	4	540	3	642	1	340	2	960	14	2,747
1960-1965	4	189	17	2,361	2	440	1	340	2	1,210	26	4,540
1966-1972	6	405	0	0	10	2,230	12	4,080	3	1,700	31	8,415
Unknown	1	30	1	100	1	210	0	0	0	0	3	340
Totals	15	889	22	3,001	16	3,522	14	4,760	7	3,870	4	16,042
Electrolytic hydrogen												
Pre-1960	4	105	1	115							5	220
1960-1965	1	23									1	23
1966-1972												
Unknown												
Totals	5	128	1	115							6	243
Ammonia Pollutants												
Pre-1960	1	70	1	133							2	203
1960-1965												
1966-1972							1	400			1	400
Unknown												
Totals	1	70	1	133			1	400			3	603
All Processes												
Pre-1960	9	440	6	788	3	642	1	340	2	960	21	3,170
1960-1965	5	212	17	2,361	2	440	1	340	2	1,210	27	4,563
1966-1972	6	405			10	2,230	13	4,480	3	1,700	32	8,815
Unknown	1	30	1	100	1	210					3	340
Totals	21	1,087	24	3,249	16	3,522	15	5,160	7	3,870	83	16,888

1/ Assume plants built 1965 and earlier are reciprocal compressor type.

Table I-4. Ammonium nitrate: Number and capacity of plants by age and capacity range (1,000 tons)

Process and age group	0 - 99		100 - 149		150 - 249		250 ---		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Prill Process										
Pre-1960	8	557	3	312	4*	786	5	1,695	20	3,350
1960-1965	13	840	3	411	3	561	1	350	20	2,162
1966-1972	5	313	5	655	2	342	1	290	13	1,600
Unknown	1	80	0	0	0	0	0	0	1	80
Totals	27	1,790	11	1,378	9	1,689	7	2,335	54	7,192

*Includes one and only Stengel process plant (187,000 TPY capacity)

Table I-5. **Urea:** Number and capacity of plants by age and capacity range (1,000 tons)

Process and age group	0 - 99		100 - 149		150 - 249		250 ---		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Total Recycle										
Pre-1960	1	40	3	365	0	0	0	0	4	405
1960-1965	3	240	1	103	0	0	0	0	4	343
1966-1972	5	325	3	368	4	755	1	350	13	1,798
Unknown	0	0	0	0	0	0	0	0	0	0
Totals	9	605	7	836	4	755	1	350	21	2,546
Partial Recycle										
Pre-1960	2	165	0	0	1	238	0	0	3	403
1960-1965	0	0	0	0	0	0	0	0	0	0
1966-1972	1	20	0	0	0	0	0	0	1	20
Unknown	0	0	0	0	0	0	0	0	0	0
Totals	3	185	0	0	1	238	0	0	4	423
Once Through										
Pre-1960	1	40	0	0	0	0	0	0	1	40
1960-1965	6	265	0	0	0	0	0	0	6	265
1966-1972	4	178	0	0	2	320	0	0	6	498
Unknown	0	0	0	0	0	0	0	0	0	0
Totals	11	483	0	0	2	320	0	0	13	803
Unknown										
Pre-1960	0	0	0	0	0	0	0	0	0	0
1960-1965	0	0	0	0	0	0	0	0	0	0
1966-1972	3	171	0	0	0	0	1	420	4	591
Unknown	0	0	0	0	0	0	0	0	0	0
Totals	3	171	0	0	0	0	1	420	4	591
All Processes										
Pre-1960	4	245	3	365	1	238	0	0	8	848
1960-1965	9	505	1	103	0	0	0	0	10	608
1966-1972	13	694	3	368	6	1,075	2	770	24	2,907
Unknown	0	0	0	0	0	0	0	0	0	0
Totals	26	1,444	7	836	7	1,313	2	770	42	4,363

Table I-6. Phosphoric acid: Number and capacity of plants by age and capacity range (1,000 tons P_2O_5)

Process and age group	0 - 74		75 - 149		150 - 249		250 ---		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Pre-1960	1	17	2	217	0	0	0	0	3	234
1960-1965	2	39	0	0	1	176	0	0	3	215
1966-1972	3	150	2	204	7	1,352	4	1,801	16	3,507
Unknown	1	15	3	360	3	550	3	1,489	10	2,414
Totals	7	221	7	781	11	2,078	7	3,290	32	6,370

Table I-7. Ammonium phosphate: Number and capacity of plants by age and capacity range (1,000 tons P_2O_5)

Process and age group	0 - 49		50 - 99		100 - 199		200 ----		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Conventional process										
Pre-1960	1	17	0	0	0	0	0	0	1	17
1960-1965	2	20	1	85	0	0	0	0	3	105
1966-1972	2	75	4	237	8	1,161	1	300	15	1,773
Unknown	7	158	5	376	5	712	1	450	18	1,696
Totals	12	270	10	698	13	1,873	2	750	37	3,591
Nitric phosphate process										
Pre-1960	0	0	0	0	0	0	0	0	0	0
1960-1965	0	0	0	0	0	0	0	0	0	0
1966-1972	1	45	0	0	0	0	0	0	1	45
Unknown	1	20	0	0	0	0	0	0	1	20
Totals	2	65	0	0	0	0	0	0	2	65
21-53-0 Process										
Pre-1960	0	0	0	0	0	0	0	0	0	0
1960-1965	0	0	0	0	0	0	0	0	0	0
1966-1972	0	0	0	0	0	0	0	0	0	0
Unknown	2	25	0	0	0	0	0	0	2	25
Totals	2	25	0	0	0	0	0	0	2	25
All Processes										
Pre-1960	1	17	0	0	0	0	0	0	1	17
1960-1965	2	20	1	85	0	0	0	0	3	105
1966-1972	3	120	4	237	8	1,161	1	300	16	1,818
Unknown	10	203	5	376	5	712	1	450	21	1,741
Totals	16	360	10	698	13	1,873	2	750	41	3,681

Table I-8. Triple superphosphate: Number and capacity of plants by age and capacity range (1,000 tons P_2O_5)

Process and age group	0 - 99		100 - 199		200 ----		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Pre-1960	1	33	0	0	0	0	1	33
1960-1965	0	0	1	121	0	0	1	121
1966-1972	3	169	3	513	1	375	7	1,057
Unknown	4	228	1	123	1	320	6	671
Totals	8	430	5	757	2	695	15	1,882

Table I-9. Normal superphosphate: Number and capacity of plants by age and capacity range (1,000 tons P_2O_5)

Process and age group	0 - 8		9 - 12		13 - 16		17 and over		Totals	
	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity	No. of plants	Total capacity
Pre-1960	--	--	--	--	--	--	--	--	--	--
1960-1965	--	--	--	--	--	--	--	--	--	--
1966-1972	--	--	--	--	--	--	--	--	--	--
Unknown	16	93	16	166	17	251	11	225	60	735
Totals	16	93	16	166	17	251	11	225	60	735

Table I-10. Horizontal integration of production - distribution of plants by number of plants at a single location

Plants per location	No. of Companies	% of Total Companies	No. of Plants	% of Total Plants
1	60	36.1	60	15.3
2	45	27.1	90	22.9
3	20	12.1	60	15.3
4	27	16.3	108	27.5
5	11	6.6	55	14.0
6	1	.6	6	1.5
7	2	1.2	14	3.5
Totals	166 [1/]	100.0	393	100.0

[1/] Only 109 firms - includes more than one location of plant operations for some firms.

Table I-11. Horizontal integration of production - present product combinations

Comb. Code	No. of Companies	NH_3	U	N.A.	A.N.	A.S.	S.A.	Wet	A.P	TSP	SPA	No. of plants
2	22	X										22
3	2				X							2
5	2		X									2
6		X	X									12
8	3	X	X		X							9
9	3						1/	X				3
17	1									X		1
25	3						1/	X		X		6
33	6								X			6
38	1	X	X						X			3
41	7						1/	X	X			14
57	3						1/	X	X	X		9
58	1	X					1/	X	X	X		4
185	1						1/	X	X	X	X	4
257	25					X						25
258	3	X				X						6
260	1	X			X	X						3
514	2	X		X								4
515	13			X	X							26
516	5	X		X	X							15
518	3	X	X	X								9
519	1		X	X	X							3
520	16	X	X	X	X							64
547	1			X	X				X			3
548	2	X		X	X				X			8
550	1	X	X	X					X			4

Table I-11 (continued)

Comb. Code	No. of Companies	NH_3	U	N.A.	A.N.	A.S.	S.A.	Wet	A.P.	TSP	SPA	No. of plants
552	4	X	X	X	X				X			20
688	1	X	X	X	X		1/	X	X		X	7
772	1	X		X	X	X						4
776	1	X	X	X	X	X						5
1026	2	X					X					4
1033	1						X					
1065	2						X	X	X			6
1066	2	X					X	X	X			8
1070	1	X	X				X	X	X			5
1081	1						X	X	X	X		4
1082	1	X					X	X	X	X		5
1209	3						X	X	X	X	X	15
1281	7					X	X					14
1321	1					X	X	X	X			4
1338	1	X				X	X	X	X	X		6
1540	1	X		X	X		X					4
1544	1	X	X	X	X		X					5
1584	1	X	X	X	X		X	X	X			7
	166 2/											391

1/ Not identified individually in data used to develop this list, but must assume existence of sulphuric acid facility as intermediate to wet acid production.

2/ Only 109 firms -- includes more than one location of plant operations for some firms.

Normal superphosphate is not considered to be a basic material for purposes of this discussion and is not included among the 44 product combinations. Fifty-seven of the 60 NSP plants are integrated vertically with ammoniation-granulation plants, while a relatively low but unknown number exists in complexes with basic product plants.

C. Number of Plants and Employment

Number of Employees

The 1972 *Census of Manufactures* shows the following data for the fertilizer industry:

SIC No.	Total Employment	Production Workers
2873 Nitrogen	9,800	6,300
2874 Phosphates	14,800	10,700
2875 Mixing only	11,300	7,100
	32,600	24,100

It is not clear whether or not these data include 100 percent of all employees of all companies engaged at every level of production; for example, producers of sulfuric acid are classified under SIC 2819 and are probably not counted in the above totals.

As an additional check-point, the Fertilizer Institute's "Fertilizer Financial Facts" for December 31, 1972, reported approximately 36,400 employees for 36 basic producers (integrated companies). While these companies do not account for all of the industry's sales, they represent a very high percentage ($2.5 million in retail sales in 1972). It seems likely that total industry employment is in the 40,000 to 45,000 range.

Unfortunately, these reports do not permit a detailed analysis by product. For this purpose, DPRA developed its own estimate of manpower requirements based on an analysis of individual unit operations. These estimates include for each industry segment the required shiftwork manpower plus an estimate of all other plant workers (foremen, maintenance, shipping, clerical, etc.). These are shown in Table I-12.

From the estimates in Table I-12, total industry manpower requirements are summarized in Table I-13. The aggregate number of workers for all product segments is 10,290. This figure represents about 22 to 25 percent of the total industry employment of 40,000 to 45,000.

Table I-12. Estimated manpower requirements for fertilizer industry segments

Product	Capacity Tons per year	Manpower/unit Shift	 Other 1/	 Total
Ammonia	50,000	9	9	18
Ammonia	105,000	12	12	24
Ammonia	140,000	12	12	24
Ammonia	350,000	15	15	30
Ammonia	525,000	18	18	36
Nitric acid	53,000	6	6	12
Nitric acid	105,000	6	6	12
Nitric acid	210,000	6	6	12
Prilled ammonium nitrate	105,000	12	12	24
Prilled ammonium nitrate	160,000	12	12	24
Prilled ammonium nitrate	350,000	12	12	24
Prilled urea	105,000	18	18	36
Prilled urea	160,000	18	18	36
Prilled urea	350,000	18	18	36
Sulphuric acid	200,000	6	6	12
Sulphuric acid	330,000	6	6	12
Sulphuric acid	600,000	6	6	12
Sulphuric acid	900,000	6	6	12
Phosphoric acid	83,000	21	21	42 2/
Phosphoric acid	200,000	21	21	42 2/
Phosphoric acid	300,000	21	21	42 2/
Normal superphosphate	24,000	12	12	24
Normal superphosphate	40,000	12	12	24
Normal superphosphate	60,000	15	15	30
Normal superphosphate	80,000	18	18	36
Diammonium phosphate	170,000	6	6	12
Diammonium phosphate	330,000	6	6	12
Diammonium phosphate	720,000	6	6	12
Granular triple superphosphate	170,000	6	6	12

1/ Includes foreman, maintenance, shipping, clerical, etc.

2/ Includes manpower for sulfuric acid section (integrated operation).

Table I-13. Estimated manpower fertilizer industry segments, 1972

Unit	Number of plants	Estimated average	Total production manpower 1/
Ammonia	83	30	2,490
Nitric acid	55	12	660
Ammonium nitrate	54	24	1,300
Urea	42	36	1,510
Sulfuric acid	53 2/	12	640
Phosphoric acid	32	42	1,340
NSP	60	28	1,680
DAP	41	12	490
TSP	15	12	180
			10,290

1/ Excludes terminal and other distribution, sales and headquarters personnel.

2/ Less H_2SO_4 facilities integrated with H_3PO_4 producers.

D. Relationship of Segments to Total Industry

To place the industry, as defined for this study, in perspective, the relationship of the various segments to the total was estimated. Three relationships--number of plants, production and employment--were estimated. Because of the complex nature of the industry, a common set of measurements could not be made for each of the relationships, thus the reader is cautioned not to make direct comparisons.

Number of Plants

Based on a total estimate of 327 plants, which excludes nitric and sulfuric acid, ammonia plants are most numerous with about 25 percent of the total. Normal superphosphate plants account for about 18 percent of all plants, while triple superphosphate plants represent only about 5 percent of the total number of plants. The remaining segments fall between the 5 and 25 percent range.

Production

Throughout most of this study, units of production or size has largely been expressed in tons of product or equivalent plant food nutrient content. Fertilizer is largely a physical quantity -- 41 million tons of gross product consumed domestically, another 5 million tons exported. However, values per unit do differ and this section is designed to give some overall perspective to the industry segments.

In 1972, retail sales of fertilizers are estimated at about $2.5 billion. This was comprised of the following plant food nutrients consumed in all forms--direct or as mixed fertilizer.

Nitrogen (N)	8.0 million tons
Phosphate (P_2O_5)	4.9 million tons
Potash (K_2O)	4.3 million tons

Based on estimates of current product mix with each nutrient group, it is estimated that the weighted average retail values of the nutrients consumed may approximate the following:

N	$175 per ton
P_2O_5	$150 per ton
K_2O	$100 per ton

Table I-14. Selected relationships of segments to total fertilizer industry, 1973

Segment	No. of plants		Production		Employment	
	No.	Percent	Plant sales ($million)	Percent 3/	No.	Percent 4/
Ammonia	83	25.4	543 2/	34	2,490	6.2
Ammonium nitrate	54	16.5	302	19	1,300	3.3
Urea	42	12.8	392	24	1,510	3.8
Phosphoric acid	32	9.8	---	--	1,340	3.4
Diammonium phosphate	41	12.5	510	32	490	1.2
Triple superphosphate	15	4.6	198	12	180	0.5
Normal superphosphate	60	18.3	117	7	1,680	4.2
Total	327 1/	100.0 5/	NA	NA	8,990	22.5 5/

1/ Excludes nitric acid plants.

2/ Includes product used as an intermediate.

3/ All values a percent of wholesale sales.

4/ All values a percent of 40,000 total workers.

5/ Column may not add due to rounding.

Thus at the above values and consumption levels, the retail value of fertilizers consumed may be estimated at about:

N	\$1.40 billion
P_2O_5	\$ .74 billion
K_2O	\$ .43 billion
	\$2.57 billion
Add total exports	\$ .34 billion
	\$2.91 billion
Less imports	\$ .20 billion
Net retail value of domestic production	\$2.71 billion

The wholesale value of the various industry segment products ranges from 50 to 68 percent of retail, thus an order of magnitude estimate of the wholesale value of all industry fertilizer production (using 60 percent) may be $1.6 billion dollars.

Using these values, Table I-15 was prepared to place some perspective on the relationship of the industry segments to the whole in terms of production measured in dollars. The relatively minor importance, in terms of sales of normal superphosphate and TSP stand out against the importance of ammonia, urea and DAP.

Employment

Relationship of the segments in this study to the total fertilizer industry employment demonstrate a pattern similar to the number of plants (see Table II-14). Triple superphosphate employs the fewest in the basic chemicals group, while ammonia employs the largest number in relation to the total.

Table I-15. Estimated wholesale value of industry segments, 1973

Product	Production	1973 F.O.B. price	Total value	Percent of estimated total wholesale
	(1,000 tons product)	($/ton)	($million)	
Ammonia	14,300 1/	$38.00	$543	34 1/
Ammonium nitrate	6,872	44.00	302	19
Urea	3,724	57.00	392	24
DAP	6,800	75.00	510	32
TSP	3,600	55.00	198	12
NSP	3,355	28.00 2/	94	6

1/ Includes ammonia used as intermediate for production of other nitrogenous fertilizers.

2/ Weighted average price of $35.00 for granular NSP and $17.50 for run-of-pile pulverized, based on 60 percent granular and 40 percent r.o.p.

II. FINANCIAL PROFILE

Financial data are extremely limited on the fertilizer industry due to the complex organization and diverse business interests of firms owning fertilizer plants. As a result, it is virtually impossible to identify segment by segment financial data from external sources. From the financial data important insights can be gained, but in the main, it is necessary to resort to model plant budgets representing the various segments of interest. Thus, to gain these insights, budgets were prepared for representative plant configurations.

A. Plants by Segment

The fertilizer industry is complex--consisting of many end products which use intermediate products (see Figure I-1 for product relationships) and several sizes of operation. The sizes of unit operations could be generalized as small, medium and large in most all of the fertilizer product categories considered in this study.

Capital and operating costs were developed for 33 distinct product-size combinations of plant operations which we believe to be representative of the fertilizer industry. This was determined after initial review of the plants comprising each segment of the industry. 1/ Also included were capital and cost estimates of a number of intermediates necessary to the buildup total capital and cost estimates for the end products used in this study. Table II-1 shows the products and typical capacities for which such estimates were developed.

Assumptions were necessary regarding source of intermediate feedstocks in some configurations. The detailed assumptions are implicit in Table II-2. All phosphate rock was charged as if purchased rather than costing out as integrated mining and processing facilities.

1/ Additional minor segment variations exist for nitrogen solutions from urea and ammonium nitrate and superphosphoric acid. However, these were not budgeted as specific effluent control costs for these segments were not provided by EPA for this study.

Table II-1. Representative plant configurations selected for cost studies

Product	Capacity TPY	Product	Capacity TPY
Ammonia	50,000	Sulfuric acid	200,000
	105,000		235,000
	210,000		330,000
	350,000		600,000
	525,000		900,000
Nitric acid	85,000	Wet phosphoric acid	50,000
	130,000		83,000
	285,000		200,000
			300,000
Ammonium nitrate, prilled	105,000	Normal superphosphate	24,000
	160,000		40,000
	350,000		60,000
			80,000
Urea Prills	52,000		
	105,000	Diammonium phosphate	170,000
	160,000		330,000
	350,000		720,000
		Triple superphosphate	170,000
			330,000

Table II-2. Prorate factors used in estimating investment and operating costs (1,000 tons)

Product Produced		Intermediate Products Used							
		Ammonia		Nitric Acid		Sulfuric Acid		Phosphoric Acid	
Unit	Unit size (1000TPY)	Required/ unit size (1000TPY)	Percent of unit	Required/ unit size (1000TPY)	Percent of unit	Required/ unit size (1000TPY)	Percent of unit	Required/ unit size (1000TPY)	Percent of unit
Nitric acid	85	25/210	12						
" "	130	38/210	18						
" "	285	82/350	23						
Ammonium nitrate	105	23/210	11	84/85	100				
" "	160	35/210	17	128/130	100				
" "	350	76/350	22	281/285	100				
Urea	52	32/105	30						
"	105	64/210	30						
"	160	98/350	28						
"	350	214/525	41						
Diammonium phosphate	170	39/50	78					80/83	100
" "	330	76/105	72					155/200	78
" "	720	166/210	79					338/340	100
Triple superphosphate	170							59/83	71
	330							115/200	58
Normal superphosphate	24					9/235	4		
	40					14/235	6		
	60					21/235	9		
	80					29/235	12		

1. Annual Profit Before Taxes

Based upon the model plant concept and configurations employed, estimated annual pretax income levels and rates (including after-tax rates of return) are displayed in Table II-3. These estimates were based upon prices, costs and utilization rates which reflect approximate 1972 conditions.

Estimated annual pre-tax income varies greatly depending upon product, plant size and sales level (price and/or utilization of capacity). Pre-tax income levels at today's prices were negative for:

- The two smallest ammonia units
- The two smallest urea units
- The smallest DAP unit
- The smallest TSP unit
- The smallest normal superphosphate unit

The large units demonstrate relatively high levels of pre-tax income, in the order of $1.4 to $3.1 million (excepting the super large DAP unit with $8.7 million). Other plant configurations show intermediate levels.

An important factor in profitability is the matter of utilization rates. In recent years, the fertilizer industry was operating at low prices and utilization resulting in very low rates of returns. The phosphate segment approximated 75 percent utilization during the 1969-70 period. With the recovery of prices and utilization this year (1973-74), the fertilizer industry is demonstrating strong pre-tax and after-tax income.

However, it should be noted that the phosphate segment is expected to drop to a 75 percent utilization level by 1977 due to expansion of capacity (see Chapter III for discussion). This suggests that this segment is likely to experience declining prices over the next 5 years, reaching negative pre-tax income levels. The key nitrogen segments are now expected to hold or improve profitability--barring any large distortions in natrual gas prices and supplies.

The invested capital, on which rates of return were calculated, was estimated by dividing replacement capital by two to obtain an approximation of average fixed assets, plus net working capital (current assets less current liabilities). This invested capital estimate is intended to approximate invested capital in reported financial data. It is recognized that this estimate is imperfect but we believe it is of an appropriate magnitude. After-tax income was computed on the basis of a constant 48 percent rate, where applicable, and does not reflect tax carry forward or back provisions.

Table II-3. Estimated income and cash flow for industry segments based on model plants

Plant configuration	Size 1,000 TPD	Percent capacity utilized	Pre-tax			After-tax		Cash flow	Cash flow as percent investment
			Income ($1,000)	ROI1/ (pct)	ROS1/ (pct)	ROI2/ (pct)	ROS2/ (pct)	($1,000)	(pct)
Ammonia	50	85	- 443	< 0	< 0	< 0	< 0	- 242	< 0
	105	85	- 236	< 0	< 0	< 0	< 0	54	0.9
	210	85	508	5.6	9.2	2.9	4.8	777	8.5
	350	85	1,072	7.5	11.6	3.9	6.0	1,490	10.5
	525	85	2,360	13.0	17.1	6.7	8.9	2,403	13.2
Ammonia nitrate	105	90	43	0.8	1.1	0.4	0.6	347	0.4
	160	90	644	8.9	10.9	4.6	5.7	793	4.6
	350	90	3,055	23.5	23.7	12.2	12.3	2,473	12.2
Urea	52	83	- 862	< 0	< 0	< 0	< 0	- 625	< 0
	105	83	- 43	< 0	< 0	< 0	< 0	347	5.4
	160	83	561	6.4	8.1	3.3	4.2	854	9.8
	350	83	2,916	18.6	19.3	9.7	10.0	2,578	16.5
Normal superphosphate	24	200 days	- 77	< 0	< 0	< 0	< 0	- 59	< 0
	40	200 days	78	14.5	6.9	7.6	3.6	75	13.9
	60	200 days	138	18.9	8.2	9.8	4.2	117	16.0
	80	200 days	198	21.7	8.8	11.3	4.5	159	17.4
Diammonium phosphate	170	94	- 200	< 0	< 0	< 0	< 0	550	4.6
	330	94	2,214	13.3	10.8	6.9	5.6	2,238	13.5
	720	94	8,747	28.6	19.6	14.9	10.2	6,736	22.0
Triple superphosphate	170	94	- 58	< 0	< 0	< 0	< 0	423	6.2
	330	94	1,417	14.2	9.9	7.4	5.2	1,477	14.8

1/ Return on invested capital.

2/ Return on sales.

Note: 1) Tax rate of 48 percent assumed; 2) Invested capital equal to 50 percent of replacement cost of fixed assets plus net working capital (10 percent of sales); and 3) Prices and costs for 1972.

2. Annual Cash Flow

Annual cash flow (after-tax income plus depreciation) has been estimated for each model plant in Table II-3. Positive cash flows were obtained for all sizes except the smallest ammonia, urea and NSP plants. The 105,000 TPY ammonia plant shows a small positive cash flow.

These small plants present a serious financial problem; they cannot be expected to sustain a negative cash flow over the long run. Some of them are disappearing already.

3. Market (salvage) Value of Assets

A reliable and comprehensive set of estimates of the value of existing fixed assets is apparently not available from secondary data sources. Development of a set of valuations would require a plant-by-plant appraisal, which is beyond the scope of this inquiry. However, some insights into this issue can be obtained from considering the nature of fertilizer plant construction, location, type of plant and other factors and the investment estimates for model plants. To set the scenario for this discussion, the model plant investment estimates are discussed first.

a. Estimated Model Plant Investment

The capital estimates developed for the end-products under study purport to represent the capital employment for all production phases of the operation. Where an intermediate product (ammonia, nitric acid, phosphoric acid, etc.) is needed for production of an end-product, it was included as a cost element at the ratio of the use of the intermediate product by the end-product to the intermediate product's total source plant production. The appropriate capital prorate for the intermediate was carried through to the end-product.

Available information was sparse and that obtained was somewhat aged. All capital requirements were based on 1972 dollars and where necessary, available data were inflated by a factor of five percent annually to be representative of present conditions. It can also be deflated by this factor to determine original cost where needed.

Table II-2 shows the intermediate prorate factors used to estimate total investment and operating costs. In some instances we have scaled an intermediate plant to match a single end-product requirement, which is not always the actual situation. An example is the nitric acid facilities scaled to match nitric acid requirements for prilled ammonium nitrate.

In actual practice, additional nitric acid may be produced at prilled ammonium nitrate facilities for co-production of a variety of nitrogen solutions. The effect of our procedure is to slightly increase the cost of the nitric acid intermediate used in the cost estimates.

The estimated investment in fixed assets for the model plant configurations is shown in Table II-4. This table shows the basic investment plus any appropriate prorate and the total plant investment. The total figure for each model plant includes the battery limit plant investment plus auxiliary investments in land, steam, power, storage and related facilities.

Net working capital (current assets minus current liabilities) requirements were computed at 10 percent of sales for all products based on 100 percent throughput. Table II-5 summarizes net working capital requirements by end-product used in the analysis. The requirements were obtained from analysis of financial data reported by the Fertilizer Institute (Fertilizer Financial Facts), IRS Industry Reports and Dun and Bradstreet financial reports on agricultural chemical companies for the period 1967-1972.

b. Estimated Salvage Values

The fertilizer industry is comprised of an extremely wide variety and size of participants. The firms involved range from the small, local independent manufacturer of mixed fertilizers with sales of $1-3 million to the large multi-national diversified company with sales of $9 billion of which fertilizer is but a small segment. Any consideration of salvage values for fertilizer producing facilities must necessarily take into account the nature of the specific operation in relation to the whole of the firm's business interests.

At the one extreme, the small, local, independent mixed fertilizer manufacturer which specializes only in mixed fertilizers would include the whole of the business (land, buildings, machinery, equipment and office furniture) in his closure decision. At the other extreme, the facilities for the basic manufacture of nitrogen and phosphate and its fertilizer derivatives are multi-million dollar units, usually a part of a large integrated chemical or fertilizer processing complex. Therefore, any consideration of closure of these fertilizer units will most likely involve only the one component out of several and not the disposition of land or common support facilities such as water systems, power and steam generation, equipment, maintenance and office buildings. Experience has revealed that closure of any single unit within these types of complexes -- whether for technical or economic reason -- has usually been followed by the construction of a larger, more efficient unit to replace the older unit.

Table II-4. Estimated investment in fixed assets for alternative fertilizer plant configurations ($1,000)

Plant	Size (1000 TPY)	NH_3	HNO_3	A.N.	Urea	H_2SO_4	A.S.	P_2O_5	DAP	TSP	NSP	Mix	Total
Ammonia	50	$8,025											$ 8,025
Ammonia	105	11,600											11,600
Ammonia	210	17,100											17,100
Ammonia	350	26,650											26,650
Ammonia	525	33,600											33,600
Nitric acid	85	2,052	$3,400										5,452
Nitric acid	130	3,078	4,250										7,328
Nitric acid	285	6,130	6,500										12,630
Ammonium nitrate	105	1,881	5,452	$2,350									9,683
Ammonium nitrate	160	2,907	7,328	3,100									13,335
Ammonium nitrate	350	5,683	12,630	5,100									23,413
Urea	52	3,480			$5,000								8,480
Urea	105	5,130			6,750								11,880
Urea	160	7,462			8,600								16,062
Urea	350	13,776			14,500								28,276
Sulfuric acid	235					$2,600							

Table II-4 (continued)

Plant	Size	NH_3	HNO_3	A.N.	Urea	H_2SO_4	A.S.	P_2O_5	DAP	TSP	NSP	Mix	Total
	(1000 TPY)												
Phosphoric acid	50							$9,000					$9,000
	83							12,500					12,500
	200							20,300					20,300
	300							27,200					27,200
	340							30,000					30,000
Normal superphosphate	24					104					512		616
	40					156					692		848
	60					234					887		1,121
	80					312					1,059		1,371
Diammonium phosphate	170	$6,260						$12,500	$3,100				21,860
	330	8,352						15,834	4,900				29,086
	720	13,509						30,000	8,750				52,259
Triple superphosphate	170							8,875		$3,400			12,275
	330							11,774		5,374			17,148

Table II-5. Estimated working capital for alternative fertilizer plant configurations ($1,000)

	Capacity	Investment
	(1,000 TPY)	($1,000)
Ammonia	50	$ 205
	105	431
	210	651
	350	1,085
	525	1,628
Ammonium nitrate	105	431
	160	656
	350	1,435
Urea	52	270
	105	546
	160	832
	350	1,820
Normal superphosphate	24	67
	40	112
	60	168
	80	224
Diammonium phosphate	170	1,122
	330	2,178
	720	4,752
Triple superphosphate	170	782

Table II-6 presents estimated salvage values for model plants. These dollar amounts are 8 percent of replacement costs plus net working capital (estimated as 10 percent of sales at 100 percent utilization).

The 8 percent factor is derived from (1) an estimated percentage weight for each plant component multiplied by (2) the expected salvage value of the component, expressed as a percentage of original cost. These percentages are as follows:

	Component Cost as a Percent of Total Cost	Salvage Value as a Percent of Original Cost	Weighted Salvage Value (Pct)
Buildings and land	5.8	25	1.46
Process equipment	25.0	25	6.25
Labor -- setting equipment	2.5	0	0.00
Process materials and labor	28.5	0	0.00
Field expenses	11.7	0	0.00
Engineering and contracting expenses, including profit	26.5	0	0.00
	100.0		7.71

The weighted salvage value percentage has been rounded to 8 percent.

4. Cost Structure

Model plant budgets were prepared to estimate the cost structure of the various segments.

Fixed or plant related expenses were defined as those which do not directly vary as a function of throughput. These expenses include:

- maintenance and supplies
- taxes and insurance
- plant and labor overhead
- sales, general and administrative

Table II-6. Salvage values by product and plant size

Plant	Size	Replacement value fixed assets	Salvage value 1/	Working capital 2/	Total salvage
Ammonia	50	8,025	642	205	847
	105	11,600	928	430	1,358
	210	17,100	1,368	651	2,019
	350	26,650	2,132	1,085	3,217
	525	33,600	2,688	1,627	4,315
Nitric acid	85	5,452	436	3/	436
	130	7,328	586	3/	586
	285	12,630	1,010	3/	1,010
Ammonium nitrate	105	9,683	775	430	1,205
	160	13,335	1,067	656	1,723
	350	23,413	1,873	1,435	3,308
Urea	52	8,480	678	270	948
	105	11,880	950	546	1,496
	160	16,062	1,285	832	2,117
	350	28,276	2,262	1,820	4,082
Phosphoric acid	50	9,000	720	3/	720
	83	12,500	1,000	3/	1,000
	200	20,300	1,624	3/	1,624
	300	27,200	2,176	3/	2,176
	340	30,000	2,400	3/	2,400
Normal superphosphate	24	543	146	117	263
	40	735	190	195	385
	60	942	239	292	531
	80	1,124	286	390	676
Diammonium phosphate	170	21,860	1,749	1,122	2,871
	330	29,086	2,327	2,178	4,505
	720	52,259	4,181	4,752	8,933
Triple superphosphate	170	12,275	982	782	1,764
	330	17,148	1,372	1,518	2,890

1/ Calculated as 8% of original investment.
2/ Calculated as 10% of 100% level sales.
3/ Reflected in end product working capital.

Additionally cost estimates were made for depreciation and interest costs. Variable or production related expenses were defined as those which will generally vary proportionately with throughput -- in other words, a fixed amount per ton. They include:

- raw materials
- power
- water
- catalysts, chemicals, etc.
- operating labor
- plant supervision and fringe benefits

a. Fixed costs

As shown in Table II-7, indirect expenses range from 28 to 71 percent of sales. These expenses for the small and intermediate basic products plants -- ammonia, ammonium nitrate, urea, DAP -- represent a significant portion of sales.

Where different sized models were evaluated, the larger plants consistently have lower indirect costs in proportion to sales. This is also true for all depreciation.

Depreciation is based on an estimated book value (50 percent of replacement cost) and estimated life of plant and equipment. Annual percentage rates are given in the expense statements for model plants (Appendix Tables 1 to 8). As a percent of sales, depreciation, ranges from 2.5 to 11.5. These percentages may overstate slightly the actual industry practice in depreciation. From available published data, the industry averages from 5 to 8 percent of sales. Interest costs, as computed, ranged from 1.6 to 2.7 percent of sales (excluding NSP plants, where long term interest has been excluded).

b. Variable Costs

Variable costs are also shown in Table II-7 for the two major components -- raw materials and other. The relatively small variance in raw material costs within a model segment generally represent differences in process and process efficiency. Generally the nitrogen segments have the lowest raw material costs -- 14 to 32 percent of sales; the phosphate segment has raw material costs of 45 to 62 percent of sales.

Other direct costs, as a percent of sales, for the nitrogen products are generally slightly smaller than raw material costs ranging from about 8 to 28 percent depending on process and plant size. The phosphate segments have very low other direct costs -- about one to four percent of sales, except for NSP, where these costs range from 8 to 13 percent.

Table II-7. Estimated sales, costs and expense ratios for industry segments based on model plants

Plant configuration	Size 1,000 TPY	Percent capacity utilized	Sales		Raw Material Costs		Other Direct Costs		Indirect Costs		Depreciation		Interest		Total Costs	
			$1,000	Percent sales	$1,000	Percent sales	$1,000	Percent sales	$1,000	Percent sales	$1,000	Percent sales	$1,000	Percent sales	$1,000	Percent sales
Ammonia	50	85	1,743	100.0	559	32.1	477	27.4	918	52.7	201	11.5	31	1.8	2,186	125.4
	105	85	3,659	100.0	1,175	32.1	857	23.4	1,508	41.2	290	7.9	65	1.8	3,895	106.4
	210	85	5,534	100.0	1,742	31.5	553	10.0	2,120	38.3	513	9.3	98	1.8	5,026	90.8
	350	85	9,223	100.0	2,904	31.5	815	8.8	3,336	36.2	933	10.1	163	1.8	8,151	88.4
	525	85	13,834	100.0	4,355	31.5	1,125	8.1	4,574	33.1	1,176	8.5	244	1.8	11,474	82.9
Ammonium nitrate	105	90	3,875	100.0	879	22.7	552	14.2	1,988	51.3	325	8.4	88	2.3	3,832	98.9
	160	90	5,904	100.0	1,267	21.5	703	11.9	2,699	45.7	458	7.8	133	2.3	5,260	89.1
	350	90	12,915	100.0	2,564	19.9	1,203	9.3	4,921	38.1	884	6.8	288	2.3	9,860	76.3
Urea	52	83	2,244	100.0	599	26.7	627	27.9	1,582	70.5	237	10.6	61	2.7	3,106	138.4
	105	83	4,532	100.0	683	15.1	1,013	22.4	2,378	52.5	390	8.6	111	2.5	4,575	100.9
	160	83	6,906	100.0	1,012	14.7	1,355	19.6	3,245	47.0	562	8.1	171	2.5	6,345	91.9
	350	83	15,106	100.0	2,176	14.4	2,504	16.6	6,075	40.2	1,062	7.0	373	2.5	12,190	80.7
Normal superphosphate	24	200 days	672	100.0	416	61.9	84	12.5	231	34.3	18	2.7	0	0	749	111.4
	40	200 days	1,120	100.0	564	50.4	89	7.9	355	31.6	34	3.0	0	0	1,042	93.0
	60	200 days	1,680	100.0	847	50.4	132	7.9	518	30.8	45	2.6	0	0	1,542	91.7
	80	200 days	2,240	100.0	1,129	50.4	177	7.9	680	30.3	56	2.5	0	0	2,042	91.1
Diammonium phosphate	170	94	10,547	100.0	5,406	51.3	197	1.9	4,202	39.8	750	7.1	192	1.8	10,747	101.9
	330	94	20,473	100.0	9,998	48.8	307	1.5	6,493	31.7	1,087	5.3	374	1.8	18,259	89.2
	720	94	44,669	100.0	19,939	44.6	548	1.2	12,458	27.9	2,188	4.9	789	1.8	35,922	80.4
Triple superphosphate	170	94	7,351	100.0	3,928	53.4	280	3.8	2,603	35.4	481	6.5	117	1.6	7,409	100.8
	330	94	14,269	100.0	7,342	51.5	468	3.3	4,074	28.6	740	5.2	228	1.6	12,852	90.1

Note: Based on 1972 prices and costs.

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c. Sales

For purposes of pricing, it was assumed that the basic products (that is, all products excepting small ammonia plants and normal superphosphate) were produced in Gulf Coast locations. The interior and Pacific Coast units will be faced with higher costs for raw materials. However, these units will also realize higher ex-plant prices within their immediate market area. Although the local producer will have certain advantages, his market area is generally small and restricted to a boundary where the more efficient producers' costs plus transportation equals the local producers' price.

Sales were estimated at 1972 estimated ex-plant prices at throughput levels which approximate the 1972 utilization rates.

Prices used in estimating sales are shown in Table II-8.

d. Cost Estimates

The cost estimates for each model plant are shown in Appendix Tables 1 through 8. The tables contain all the basic values used in arriving at the cost estimates; they will allow the user of this report to review all of the underlying computations. The format of these tables is designed to permit relatively easy substitution of new data and recomputation of the estimates. Product related costs are given in dollars per ton while plant related costs are given as annual dollars. The basic numbers used in the plant related expenses category are the investments from Table II-3, or the labor base from the product related expenses used in computing overhead (production labor/ton X throughput X 100 percent) or sales as used in computing S, G & A. All plant related costs were computed on the basis of 100 percent throughput and held constant for all subsequent utilization rates.

The prorate entries refer to the allocation of plant related expenses of intermediates to the end product plant expenses. These plant related costs were allocated according to the prorate percents given in Table II-2. Product related costs were passed along based on the product related expense of the respective intermediates. In the event the user of this report wishes to deal with a complex other than that costed in this report, he can insert the appropriate new intermediate cost prorate and multiply by unit requirements and quickly recompute costs.

Table II-8. Prices used in estimating sales for model plants

Product	Price ($ per ton)
Ammonia	31 1/
Ammonium nitrate	41
Urea	52
Normal superphosphate	28 2/
Diammonium phosphate	66
Triple superphosphate	46

1/ For the two small plants 50,000 and 105,000 TPY, a price of $41.00 per ton was used to reflect localized conditions associated with small units.

2/ Based on a price of $35.00 for granular and $17.50 for pulverized, weighted at 60 and 40 percent respectively.

Depreciation costs were estimated for each segment on the basis of estimated replacement investment divided by two and expected typical life. Age of plant, depreciation methods and modernization programs will all contribute toward variances from this amount by individual production units.

Interest costs were based upon the reported industry relationship, interest costs to sales of 1.5 to 2.5 percent. This value, based upon financial data from the Fertilizer Institute and other published sources, apparently represents long term debt only; short term debt interest charges are included in sales, general and administrative expenses.

Because of the dynamic nature of the fertilizer industry, some critical cost factors may change significantly as could the financial data. These factors are discussed below.

The model plant budgets used in this study to determine profitability and cash flows are based on the most up-to-date information available to us and, we feel, they accurately represent the current situation. However, the fertilizer industry seems to be in a transitory period regarding:

Raw material availability and prices
Supply/Demand relationships
End-product sales prices
Profitability and cash-flow
Attitudes toward pollution abatement

Between now and 1975/76 the following considerations, in our judgment, serve as guidelines to assess what may be the interim situation.

(1) Raw Material Availability and Prices

Natural Gas - Price increases appear imminent for new ammonia producers. Old producers tied to long term contracts will experience escalating prices upward only at individual natural gas contract expiration dates. Gulf Coast prices for new contracts are estimated to escalate from today's prices as follows:

Year	¢MSCF	
1972	31	($.26 at wellhead plus $.05 for transmission)
1973	33	
1974	42	
1975	45	
1976	49	
1977	51	

The Midwest price is expected to be $0.15/MSCF above the Gulf Coast price. The overall outlook may change pending developments among energy companies, government regulatory agencies and public interests. However, the overall natural gas situation would appear relatively favorable as shown below:

	Trillion SCF.	
	1972	1967
Production	22.5	18.4
Additions to Reserves	9.6	21.8
Proven Reserves	266.1	292.9
Potential Reserves	1,178.0	1,200.0 est.

Phosphate Rock - The phosphate rock situation has changed from a recent overcapacity and depressed prices condition to a balanced supply/demand relationship and rising prices. Prices increased recently by $1.00 per ton. World capacity is now at 103 million tons per year. An additional 5.2 million tons of capacity is expected in 1973. Operating rates are now at 90 percent. If no new capacity commitments are made, critical shortages could be experienced after 1975.

Sulfur - The recent price increase of $3.00 per ton largely resulted from Canadian action to disallow raw sulfur (non-liquid, unflaked) to move through west coast terminals because of pollution problems. Alberta stocks of 7.0 million tons were frozen and caused temporary supply tightness. Prices are expected to hold fairly stable.

(2) Supply/Demand Relationships

Ammonia - Critical ammonia shortage appears imminent. The natural gas shortage and inability to obtain long-term supply commitments has halted further plant expansion. Prices of ammonia and its derivatives may experience a short run but substantial increase during 1973-75.

Phosphoric Acid and Derivatives - Plant overcapacity in the phosphate industry appears imminent by 1975-76, although present supplies are tight and interim prices may further increase. However, should indicated capacity increases come on stream as planned, a severe and traumatic price deterioration slightly before and during 1975/76 is expected to occur.

(3) Attitudes Toward Pollution Abatement

Future trends in sales prices, profitability and cash-flow are implied by the expectations. Thus the two major segments, nitrogen and phosphate, of the fertilizer industry appear to be on divergent paths and consequently will have divergent attitudes toward pollution abatement.

In general, the nitrogen industry is expected to hold a cooperative attitude toward pollution abatement. The phosphate industry is expected to hold a less cooperative attitude. However they have had prior options and reasons to recover certain fluoride effluents at a profit. Therefore, compliance in this specific, but major area of abatement, may already be a fait accompli.

B. Distribution of Model Plant Financial Data

In section A above, model plant financial data were reported for each product segment. These will not be repeated here, except to show how the levels of returns on investment relate to numbers of plants by size in the various groupings. Table II-9 presents these distributions.

Table II-9 shows appreciable numbers of plants operating at a loss in 1972.

Segment	Percent of capacity operating at a loss
Ammonia	25
Ammonium nitrate	0
DAP	29
TSP	23
NSP	13

In addition, 44 percent of ammonia nitrate capacity appears to be operating at a break even point.

C. Ability to Finance New Investment

The ability of a firm to finance new investment for pollution abatement is a function of several critical financial and economic factors. In general terms, new capital must come from one or more of the following sources: (1) funds borrowed from outside sources; (2) new equity capital through the sale of new common or preferred stock; (3) internally generated funds -- retained earnings and the stream of funds attributed to depreciation of fixed assets.

Table II-9. Distribution of returns on investment by product and by model plant size, 1972

Plant configuration	Size 1,000 TPY	No. plants	Total capacity (000 TPY)	% of segment capacity	Percent R.O.I. (after tax)
Ammonia	50	21	1,087	6	<0
	105	24	3,249	19	<0
	210	16	3,522	21	2.9
	350	15	5,160	31	3.9
	525	7	3,870	23	6.7
Ammonia Nitrate	105	38	3,168	44	0.4
	160	9	1,689	23	4.6
	350	7	2,335	32	12.2
Urea	52	26	1,444	33	<0
	105	7	836	19	<0
	160	7	1,313	30	3.3
	350	2	770	18	9.7
Diammonium Phosphate	170	26	1,058	29	<0
	330	13	1,873	51	6.9
	770	2	750	20	14.9
Triple Superphosphate	170	8	430	23	<0
	330	7	1,452	77	7.4
Normal Superphosphate	24	16	93	13	<0
	40	16	166	23	7.6
	60	17	251	34	9.8
	80	11	225	31	11.3

Note: All model plant sizes are expressed in tons of product. Total capacity column shows tons of product for nitrogen segment and tons of P_2O_5 for phosphate segment.

For each of the three major sources of new investment, the most critical set of factors is the financial condition of the individual firm. For debt financing, the firm's credit rating, earnings record over a period of years, stability of earnings, existing debt-equity ratio and the lenders' confidence in management will be major considerations. New equity funds through the sale of securities will depend upon the firm's future earnings as anticipated by investors, which in turn will reflect past earnings records. The firm's record, compared to others in its own industry and to firms in other similar industries, will be a major determinant of the ease with which new equity capital can be acquired. In the comparisons, the investor will probably look at the trend of earnings for the past five or so years.

Internally generated funds depend upon the margin of profitability and the cash flow from operations. Also, in publicly held corporations, stockholders must be willing to forego dividends in order to make earnings available for reinvestment.

The condition of the fertilizer industry and the general economy are also major limiting factors in attracting new capital. The industry will be compared to other similar industries (other manufacturing industries) in terms of net profits on sales and on net worth, supply-demand relationships, trends in production and consumption, the state of technology, impact of government regulation, foreign trade and other significant variables. Declining or depressed industries are not good prospects for attracting new capital. At the same time, the overall condition of the domestic and international economy can influence capital markets. A firm is more likely to attract new capital during a boom period than during a recession. On the other hand, the cost of new capital will usually be higher during an expansionary period. Furthermore, the money markets play a determining role in new financing; the 1973 year has been viewed as especially difficult for new equity issues.

These general guidelines can be applied to the fertilizer industry by looking at general economic data, industry performance and available corporate records.

The general economic outlook for the next few years is for continued economic expansion at the historic 3.5 percent annual rate, expressed in constant dollars. The 1973 rapid growth shows evidence of slowing in the latter part of the year. In spite of cyclical flucuations, the American economy should sustain its long-term growth through the

1974-77 period. Inflation and unemployment will undoubtedly continue as major problems and international economic affairs will exert significant pressures on the domestic economy. Demand for capital will remain high in relationship to supply and interest rates will probably stay high by historic stands. The cost of financing new investment will be high compared to the 1950's and early 1960's.

1. Industry Profitability

The fertilizer industry is experiencing a major upswing in prices and profitability. After a stable period of reasonable earnings during the early 1960's, the industry suffered declining prices and earnings from 1966 through 1969.[1/] (See Table II-10) Certain basic producers actually incurred negative pre-tax margins on sales in 1968, 1969 and 1970. The uptrend began in 1970 after six years of declining margins. The pretax margin in 1972 rose to 5.85 percent after declining to negative 8.5 percent in 1969. There is still a substantial gap between 5.85 percent and the 12.0 percent pretax margin of 1961.

Further financial data on the fertilizer industry are extremely limited. The producers are, for the most part, integrated, diversified corporations or cooperatives which do not report separately on fertilizer operation. It is not possible to obtain actual data about capital structure and operating ratios for the fertilizer segments of the large chemical and petrochemical companies in which fertilizer sales may constitute only a small percentage of total sales but judgments can be formed. From limited data, several generalizations are possible.

[1/] The data on the fertilizer industry in this section is from "Fertilizer Financial Facts" and "Financial Survey," furnished by the Fertilizer Institute. Data on basic integrated producers (Group II) reflect reports from 36 companies in 1972 and 38 companies in 1971, with a variable number reporting on different items. Profits are reported only before taxes and interest. Liabilities are not reported. However, the ratio of profits before taxes and interest to sales, to invested capital and to net worth are given, along with dollar figures for total assets, net sales, net operating income before taxes and interest. From these ratios and dollar values, it is possible to calculate long-term debt. The after-tax profit has been calculated by assuming 6 percent interest on long-term debt and a 48 percent federal income tax on after interest profit. This results in an after-tax profit of 2.3 percent on sales and 4.3 percent on net worth.

Table II-10. Averages of certain financial ratios for selected fertilizer companies, 1960 - 1972

	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960
Net sales	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cost of goods sold	79.8	81.3	83.3	89.6	85.9	79.3	77.8	76.6	76.1	75.6	76.2	75.8	76.4
Gross margin	20.2	18.7	16.7	10.4	14.1	20.7	22.2	23.4	23.9	24.4	23.8	24.2	23.6
S. G. &A. expense (total)	15.1	15.7	18.9	18.9	17.4	15.8	13.7	13.0	13.1	12.7	12.7	12.2	11.7
Pretax margin	5.9	3.9	(2.2)	(8.5)	(3.3)	4.9	8.5	10.4	10.8	11.7	11.1	12.0	11.9

Source: The Fertilizer Institute, "Financial Survey," and "Fertilizer Financial Facts," December 31, 1971 and June 30, 1972.

Comparing the industry's 1972 profitability to other manufacturing industries as published by Fortune magazine, [1] the fertilizer industry does not fare well. In the Fortune industry medians report, the range in return on stockholders' equity was from 5.9 percent in the textile industry to 16.0 percent in foods and cosmetics. The 36 basic producers reported by the Fertilizer Institute had a pre-tax and pre-interest return on net worth of 10.9 percent. After estimating interest and taxes, the return on equity drops to 4.3 percent -- lower than any industry in the Fortune Survey. Chemicals, as an industry, earned 9.0 percent. Return on sales (net profit after taxes as a percent of sales) reflects only a slightly better performance for the industry. The Fortune range was from 2.2 percent for the food industry to 12.8 percent for mining. The pre-tax and pre-interest margin for the fertilizer companies was 5.85 percent; the estimated after tax profit was 2.3 percent. Chemicals earned 4.4 percent on sales in the Fortune survey.

These comparisons reveal that in 1972, even though the industry improved over the previous five years, the earnings picture was extremely low in comparison to other manufacturing industries. At the same time, the trend is sharply upward for fertilizers and 1973 price and production increases give certain evidence of improved profit margins.

Other comparisons support the view that the industry is improving. Total net sales outstanding for the 36 basic producers in 1971 equaled 104 days; this dropped to 90 days in 1972, indicating lower inventories.

Most industry financial series are reported on chemicals as a broad group or on agricultural chemicals, including fertilizers. As revealed earlier, chemicals showed much stronger earnings (roughly doubled) than did the Fertilizer Institute's basic producer's group. In general, the performance of basic chemicals is not an appropriate measure for fertilizers. For example, one report [2] presented data on "fertilizers and other agricultural chemicals" for the 1967-68 fiscal year, showing net income to net worth of 5.1 percent and a 2.8 percent on invested capital. For "basic chemicals," the same report showed a 9.0 percent return on net worth and a 6.0 percent profit on invested capital.

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[1] "Industry Medians," Fortune, May, 1973, p. 244.

[2] Almanac of Business and Industrial Financial Ratios, 1971 edition, Prentice-Hall, pp. 61 and 67.

In another report for 1971, 1/ the median firm in "agricultural chemicals" earned 2.1 percent on sales and 7.1 percent on net worth, while the median firm in "industrial chemicals" earned 3.67 percent on sales and 7.7 on net worth. Again, the Fertilizer Institute group showed a pre-tax and pre-interest profit of 3.9 percent on sales in 1971; no return on equity can be calculated from the report for 1971.

Another interesting insight can be obtained by comparing total net sales per employee of fertilizer companies with those achieved by industries monitored by Fortune. The fertilizer group has $67,697 sales per employee, second only to the petroleum refining industry ($116,868) which is the highest of all industries reported; the fertilizer companies have sales per employee almost twice as large as the chemical industry ($38,602).

When comparing assets invested per employee, the fertilizer group has $75,647 per employee, which would be the third largest average U.S. industry. The largest amount of assets per employee in the Fortune survey is in the petroleum industry ($126,775); the second largest is the mining industry ($84,775).

Finally, it is worthwhile to compare the total asset-turnover of the fertilizer industry with those industries listed by Fortune. According to the 1973 Fortune survey, the ratio was 1.15 for the 500 industrials companies. The fertilizer group reported only .89. This shows the overcapacity in the industry; it also points to older, less efficient equipment and buildings.

2. Capital Structure

Similar data problems were encountered for capital structure ratios. The basic chemical industry has a fixed debt to net worth ratio of about .4 against a total liabilities to net worth ratio of .8 in 1970 and 1971. 2/ The 36 basic producers group reported by the Fertilizer Institute in 1972, the only data available, indicated a fixed debt to [illegible] worth ratio of about .4, but against an indicated total liabilities to net worth ratio of 1.1. This suggests that the fertilizer industry has somewhat higher current liabilities than does the basic chemicals industry.

1/ 1971 Key Business Ratios, "Median Firms - Agricultural Chemicals," Dun and Bradstreet, 1972.

2/ Almanac of Business and Industrial Financial Ratios, 1971 edition, Prentice-Hall.

3. Ability to Finance New Investment

On balance, it would appear that the fertilizer industry as a whole should not experience serious problems in financing new investment although the industry appears to have a cyclical earnings pattern. The picture is confused further by the dominance of large diversified firms. The basic producers -- ammonia and phosphate products -- have relatively high cash flows, even in face of low earnings. The new round of phosphate expansion suggests that capital can be obtained, at least by the larger firms, which dominate, and the prospective earnings for the nitrogen segment suggest this group should not have difficulty in financing facilities.

III. PRICING

A. Price Determination

An examination of pricing practices in the fertilizer industry produces an impression of a lack of controllable standards. This unstable situation reflects the competitive nature of the industry and periodic supply-demand imbalances at both retail and wholesale levels. This situation is compounded by a lack of price leadership, a changing configuration in distribution and new production processes.

1. Demand

Aggregate Demand for Fertilizer

Fertilizers are those industrially manufactured compounds used to supply the principal plant nutrients--nitrogen, phosphorous, and potash. As is the case for other farm inputs, use is influenced by its own price, price of other inputs, and by farm product prices. Additionally, changes in farm production technology and acreage restrictions influence fertilizer use. Overall, prices of fertilizers (based on price per unit of plant nutrient) gradually increased from 1932 to the early fifties and then declined until 1969-70. Fertilizer prices dropped about 5 percent during the mid-fifties. The price decline moderated from 1955 to 1961 with a 1.5 percent drop in prices. However, in the ten year period from 1961 to 1971, fertilizer prices declined 15 percent--based on the change in the farm price of direct application products. If the price of fertilizer is the major determinant of fertilizer use, then the decline in prices would only account for the increase in use since the mid-1950's. Incorporating farm prices greatly improves the explanation. The price of fertilizer relative to farm product prices indicates the cost of an input relative to the value of the output. The price of a unit of plant nutrient relative to the price of all crops fell 50 percent from 1940 to 1950. This fall was the result of a substantial rise in prices received for crops and a relatively small rise in the price paid for fertilizer. During this same period fertilizer use trebled. The continued increase in fertilizer use since the mid-1950's also reflects the decline in this price ratio (see Table III-1). However, during the latter period the decline in fertilizer prices was the contributing factor. Not only have the changes in product price to input price ratio been favorable, but fertilizer prices have also declined relative to other farm inputs encouraging substitution of fertilizers for other farm inputs. The availability of land as an input

Table III-1. U.S. consumption of fertilizers and plant nutrients, 1950-1973

Fertilizer Year	Total fertilizer material	Plant Nutrients			
		Nitrogen (N)	Phosphates (P_2O_5)	Potash (K_2O)	Total
			(short tons)		
1950	18,343,300	1,005,452	1,949,768	1,103,062	4,058,282
1955	22,726,462	1,960,536	2,283,660	1,874,943	6,119,139
1960	24,877,415	2,738,047	2,572,348	2,153,319	7,463,714
1961	25,567,130	3,030,788	2,645,085	2,168,533	7,844,406
1962	26,615,037	3,369,980	2,807,039	2,270,537	8,447,556
1963	28,844,480	3,929,089	3,072,873	2,503,462	9,505,424
1964	30,681,016	4,352,809	3,377,841	2,729,693	10,460,343
1965	31,836,403	4,638,538	3,512,207	2,834,537	10,985,282
1966	34,532,215	5,326,303	3,897,132	3,221,245	12,444,680
1967	37,081,315	6,026,997	4,304,688	3,641,799	13,973,484
1968	38,552,044	6,693,790	4,451,980	3,792,013	14,937,783
1969	38,948,517	6,957,600	4,665,569	3,891,576	15,514,745
1970[a/]	39,588,637	7,459,004	4,573,758	4,035,511	16,068,264
1971[b/]	41,118,272	8,133,606	4,803,443	4,231,369	17,168,418
1972[b/]	41,205,839	8,016,007	4,873,053	4,332,016	17,221,077
1973	(est)	8,600,000	5,200,000	4,700,000	18,500,000

[a/] 1970 data from *Commercial Fertilizers*, No. 5-72, SRS, USDA, Washington, D.C., May, 1972.

[b/] 1971 and 1972 data from *Commercial Fertilizers*, No. 5-73, SRS, USDA, Washington, D. C., May 1973.

Source: *Fertilizer Trends*, no. Y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, December 1971, p. 5.

has been restricted through acreage allotments and diversions which encouraged farmers to increase fertilizer as a means of increasing output under acreage restrictions. Finally, technological developments in farming help to encourage fertilizer use.

Griliches found that a lag relationship of fertilizer prices relative to the price of all crops explained over 95 percent of the variation in per acre fertilizer use from 1911 to 1956.[1] Furthermore, he divided the study period into two subperiods and found no significant difference in farmer response between the latter and former periods. He estimated short run price elasticity of demand at -0.5 and long run elasticity at -2.0. The lag structure showed farmers making a 25 percent adjustment annually towards the desired level. Tweeten has subsequently modified these findings.[2] He concludes that the short run elasticity of demand is -0.6 while the long run elasticity is -1.8.

Fertilizer Forms and Prices

The most rapid growth in fertilizer usage has been in direct application materials. Fifty-two percent of all fertilizer materials used in 1972 were mixed fertilizers, compared to 67 percent in 1950 and 63 percent in 1960. Plant nutrient content of mixtures and direct application materials was almost equal in 1972. The heavier use of direct application materials along with higher analysis materials, raised the average analysis of all materials from 22.7 percent in 1950 to 43.2 percent in 1972.

Nitrogen - The United States used 8,016 tons of nitrogen as fertilizer in 1972, down 1.5 percent from 1971. Nitrogen from mixtures accounted for 2,135,921 tons in 1972 (up 4 percent from 1971), while nitrogen from direct application materials was 5,880,086 tons (down 3 percent from 1971). Table III-2 shows the trend in nitrogen consumption since 1950.

The primary sources of nitrogen by direct application materials in 1972 were anhydrous ammonia (2,982,274 tons), ammonium nitrate (1,015,548 tons) and nitrogen solutions (1,009,119 tons)(Table III-3).

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[1] Griliches, Zvi, "The Demand for Fertilizer: An Economic Interpretation of a Technical Change", Journal of Farm Economics, 40:3, August, 1958, pp. 591-606.

[2] Tweeten, Luther, "Market Growth Factors," Searching the Seventies, Conf. Proc., TVA Fertilizer and Production Marketing Conference, September 15-17, 1971 (Memphis, Tenn.), pp. 24-30.

Table III-2. U. S. Nitrogen consumption, 1950-1972

Fiscal Year	Total Nitrogen Consumption	Nitrogen in Mixtures	Direct Application Materials		
			Fluid	Solid	Total
			(short tons of nitrogen)		
1950	1,005,452	495,360	75,556	434,536	510,092
1955	1,960,536	803,541	375,316	781,679	1,156,995
1960	2,738,047	1,017,415	862,044	858,588	1,720,632
1961	3,030,788	1,071,224	1,045,289	914,275	1,959,564
1962	3,369,980	1,147,266	1,238,587	984,127	2,222,714
1963	3,929,089	1,263,641	1,594,602	1,070,846	2,665,448
1964	4,352,809	1,377,033	1,832,357	1,143,419	2,975,776
1965	4,638,538	1,452,084	2,041,760	1,144,694	3,186,454
1966	5,326,303	1,591,927	2,520,131	1,214,245	3,734,376
1967	6,026,997	1,764,372	2,935,163	1,327,462	4,262,625
1968	6,693,790	1,867,091	3,423,400	1,403,299	4,826,699
1969	6,957,600	1,901,393	3,560,071	1,496,136	5,056,207
1970	7,459,004[a]	1,939,077[a]	3,957,718	1,562,208	5,519,927[a]
1971	8,133,606[a]	2,062,782[a]	4,218,466	1,651,205	6,070,824[a]
1972	8,016,007[a]	2,135,921[a]	4,141,558[a]	1,738,528[a]	5,880,086[a]

[a] 1970, 1971 and 1972 data from Commercial Fertilizers, no. 5-72, SRS, USDA, Washington, D.C., May 1972 and No. 5-73, May 1973.

Source: Fertilizer Trends, no. y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, December 1971, p. 9.

Table III-3. Consumption of nitrogen from major direct application nitrogen materials in the U. S., 1950-1972

Fiscal Year	Anhydrous Ammonia	Aqua Ammonia	Nitrogen Solutions	Ammonium Nitrate	Urea	Ammonium Sulfate
			(short tons of nitrogen)			
1950	70,123	2,323	3,110	190,595	8,253	46,933
1955	290,337	46,617	38,362	375,318	30,973	103,994
1960	581,924	85,380	194,740	415,855	64,596	106,959
1961	666,234	86,489	292,566	446,585	92,448	115,715
1962	767,425	99,783	371,379	468,523	132,804	116,687
1963	1,006,762	116,448	471,392	499,378	165,198	147,121
1964	1,148,071	157,531	526,755	555,320	184,327	148,865
1965	1,281,968	163,933	595,859	547,488	193,713	161,848
1966	1,606,872	200,814	712,445	610,705	211,615	165,797
1967	1,973,596	177,175	784,392	710,503	227,952	174,834
1968	2,457,261	163,047	803,092	786,346	243,359	167,306
1969	2,576,431	143,715	839,925	863,792	264,755	157,042
1970	2,844,058	143,778	969,882	952,861	242,758	160,911
1971[a/]	3,254,160	151,321	1,036,498	969,091	273,607	185,386
1972[a/]	2,982,274	150,165	1,009,119	1,015,548	357,386	192,205

[a/] 1971 and 1972 data from Commercial Fertilizers, no. 5-72, SRS, USDA, Washington, D.C., May 1972 and no. 5-73, May 1973.

Source: Fertilizer Trends, no. y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, December 1971, p. 9.

These three materials supplied 85 percent of the nitrogen in the direct application and 62 percent of all nitrogen. Nitrogen in urea (357,386 tons), ammonium sulfate (192,205 tons), aqua ammonia (150,165 tons) and phosphate materials (93,686 tons) accounted for all but one percent of the remaining nitrogen in direct application materials.

In 1950, anhydrous ammonia contributed 14 percent of the nitrogen in direct application materials used, compared to 54 percent in 1971 and 51 percent in 1972. This trend becomes more meaningful when considered alongside another: Only about 50 percent of all nitrogen consumed as fertilizer in 1950 came from direct application materials, whereas 73 percent came from that source in 1972. This means that anhydrous ammonia supplied 37 percent of all nitrogen used as fertilizer in 1972.

The use of urea also increased markedly from 8,253 tons in 1950 to 30,973 tons in 1955 and to 357,386 tons in 1972. But as a percent of all nitrogen from direct application materials, urea rose only from 2.7 percent in 1955 to 6.1 percent in 1972.

This change in distribution of primary sources of nitrogen resulted from changes in relative costs of nitrogen products as seen in Table III-4. Price of anhydrous ammonia declined 44 percent from 1961 to 1972, urea 30 percent, ammonium nitrate 22 percent and ammonium sulfate 10 percent. A recent Michigan State University study projects continued adjustments towards the more economical sources of nitrogen, especially anhydrous ammonia.

Phosphate - The use of phosphate fertilizers generally increased in the United States in 1972. The P_2O_5 content of all fertilizer materials in 1972 rose from 4,803,443 in 1971 to 4,873,053 tons.

Table III-5 reveals that the 1972 use of P_2O_5 was 82 percent through mixtures (including diammonium phosphates 18-46-0 and 16-48-0) and 18 percent through direct application materials. Diammonium phosphates accounted for 18 percent of all P_2O_5 used and 21 percent of the P_2O_5 consumed in mixtures in 1972. Concentrated superphosphates (over 22 percent P_2O_5) supplied 13 percent of all P_2O_5 used and 71 percent of direct application materials (excluding 18-46-0 and 16-48-0). Normal superphosphates, which in 1950 furnished 61 percent of P_2O_5 in direct application materials and 19 percent of all P_2O_5 used, accounted for only 43,553 tons in 1972--less than one percent of total consumption.

Table III-4. **Average prices paid by farmers per 20-pound unit of nitrogen contained in nitrogenous materials, United States, 1961-73**[1]

April 15 of year	Ammonium sulfate	Ammonium nitrate	Urea	Anhydrous ammonia	Nitrogen solutions percent N 28	30	32
	Dollars						
1961	2.84	2.47	2.51	1.73	-	-	-
1962	2.78	2.44	2.40	1.63	-	-	-
1963	2.55	2.42	2.35	1.56	-	-	-
1964	2.57	2.38	2.33	1.54	-	-	-
1965	2.60	2.35	2.29	1.49	-	-	-
1966	2.58	2.28	2.22	1.45	-	-	-
1967	2.64	2.21	2.18	1.38	-	-	-
1968	2.63	2.03	2.02	1.11	1.95	2.09	2.06
1969	2.56	1.84	1.84	.92	1.49	1.79	1.80
1970	2.56	1.79	1.82	.91	1.64	1.81	1.83
1971	2.52	1.89	1.80	.97	1.79	1.87	1.90
1972	2.54	1.93	1.79	.98	1.85	1.84	1.96
1973	2.69	2.13	1.98	1.07	2.05	1.94	2.09

[1] Excludes Alaska and Hawaii

Source: Fertilizer Situation, December, 1972; 1973 prices computed from Agricultural Prices, PR 1(4-73), Statistical Reporting Service, USDA, April 1973.

Table III-5. U.S. phosphate consumption, 1950-1972

Fertilizer Year	Total Consumption	Mixtures	Direct Application Materials: Superphosphates	Direct Application Materials: Ammonium Phosphates[a]	Direct Application Materials: Total	Diammonium Phosphates[b]
			(short tons of P_2O_5)			
1950	1,949,768	1,344,295	490,605	34,243	605,473	
1955	2,283,660	1,821,087	291,406	84,617	462,573	113
1960	2,572,348	2,033,316	287,335	171,329	539,032	35,278
1961	2,645,085	2,069,425	303,256	188,398	575,660	63,482
1962	2,807,039	2,219,444	313,860	204,768	587,595	110,074
1963	3,072,873	2,473,599	318,415	205,457	599,274	177,487
1964	3,377,841	2,704,985	382,287	215,604	672,856	244,271
1965	3,512,207	2,816,056	403,403	204,401	696,151	302,088
1966	3,897,132	3,110,784	506,351	220,908	786,348	417,821
1967	4,304,688	3,502,897	517,470	223,761	801,791	451,452
1968	4,451,980	3,579,140	566,120	227,288	872,840	608,296
1969	4,665,569	3,724,237	656,713	207,448	941,332	723,786
1970	4,573,758	3,709,062	608,338	183,688	864,697	726,486
1971[c]	4,803,443	3,943,372	610,969	178,878	860,071	814,183
1972[c]	4,873,053	4,006,595	620,059	174,277	866,458	882,689

[a] Includes grades 11-48-0, 13-39-0, 16-20-0, 21-53-0, and 27-14-0.

[b] Includes 18-46-0 and 16-48-0 classified as mixed fertilizer

[c] 1971 and 1972 data in Commercial Fertilizers, no. 5-72, SRS, USDA, Washington, D. C., May 1972 and 5-73, May 1973.

Source: Fertilizer Trends, no. y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, December, 1971, p. 16.

The growth in P_2O_5 consumption has been largely through the use of 18-46-0 and concentrated superphosphates (over 22 percent P_2O_5). In 1960, these two sources supplied 194,157 tons of P_2O_5 (5 percent of which was 18-46-0), which accounted for about 7 percent of all P_2O_5 consumed. In 1972, the two types furnished 1,439,323 tons of P_2O_5 (60 percent of which was 18-46-0), or 30 percent of all P_2O_5 used. Grade 18-46-0 passed concentrated superphosphates in importance in 1968. Since that year, 18-46-0 usage has increased 50 percent, while concentrated superphosphates have increased 18 percent. Thus, 18-46-0 is the most rapidly expanding source of P_2O_5 in commercial fertilizers.

Again, shifts in utilization reflect changes in prices of products involved. Price of concentrated superphosphates declined 5 percent from 1961 to 1972 and ammonium phosphate price declined 12 percent, while normal superphosphate price increased 35 percent (Table III-6).

Foreign Trade

In 1972, the United States exported 18.8 million tons of fertilizer materials. The largest single item was phosphate rock (13.6 million tons). Significant amounts of ammonium sulfate, anhydrous ammonia, ammonium phosphates, concentrated superphosphates, potassium chloride, urea and mixed fertilizers were also exported. The declared values of fertilizer exports were in excess of \$339 million. Exports of nitrogen and phosphate amounted to about 17 percent of domestic production in 1972. Both tonnage and declared values increased in 1971-72 over 1970-71 after declines of two years (see Tables III-7, 8, and 9).

Total tonnage rose by 7 percent and total declared value rose by 17 percent, reflecting stronger export prices of several materials in 1971-72. Export tonnages of urea, phosphate rock, concentrated superphosphate, ammonium phosphate and potassium chloride increased significantly, while tonnages of anhydrous ammonia, ammonium nitrate, ammonium sulfate and fertilizer materials declined.

Fertilizer exports go to more than 50 countries, with 32 percent of the tonnage to Europe, 26 percent to Asia, 25 percent to North American neighbors and 15 percent to South America. The chief countries are Canada, Japan, Brazil, Italy, West Germany and Mexico in that order. These six countries buy over 60 percent of U.S. fertilizer exports by weight. Other countries of some limited importance are the Netherlands, Belgium-Luxembourg, France, India and Korea.

The largest tonnages to all eleven of the above countries are phosphate rock, which accounts for 72 percent of all export tonnage. When destinations are analyzed for other important materials, there is a high degree of concentration of exports.

Table **III-6.** **Average prices paid by farmers per ton for selected fertilizers, United States, 1957-59 average, and 1967-73**

April 15 of year	Anhydrous ammonia	Superphosphate 46 percent P_2O_5	Superphosphate 20 percent P_2O_5	Ammonium phosphate 16-20-0	Potash 60 percent K_2O	Mixed fertilizer 6-24-24
	Dollars					
Average 1957-59	149.00	82.20	37.00	89.60	1/56.80	-
1967	113.00	84.10	42.10	80.70	1/58.50	85.70
1968	91.40	78.40	43.20	78.40	49.10	81.80
1969	75.60	74.00	43.80	77.70	47.80	73.20
1970	75.00	75.10	45.40	76.90	50.90	75.00
1971	79.30	76.60	47.80	76.70	58.20	80.30
1972	80.00	78.00	49.90	79.00	58.80	81.00
1973	87.60	87.50	53.70	83.90	61.50	88.00

[1] **Based on equivalent price for 55 percent K_2O reported by SRS.**

Source: Fertilizer Situation, FS-3, ERS, USDA, Washington, D.C., December, 1972; Agricultural Prices, Pr 1 (4-73), Statistical Reporting Service, USDA, April 1973, and earlier issues.

Table III-7. Exports of selected fertilizer materials, 1969-1972

Material	1969		1970		1971		1972	
	Tons 1/	Value	Tons 1/	Value	Tons 1/	Value	Tons 1/	Value
	(1,000)	(Million)	(1,000)	(Million)	(1,000)	(Million)	(1,000)	(Million)
Anhydrous ammonia	539	$30.6	764	$21.7	598	$19.7	421	$13.2
Ammonium nitrate	110	5.0	81	4.1	59	3.0	34	1.9
Ammonium sulfate	1,185	40.2	528	16.0	601	9.2	558	9.8
Urea	565	35.6	670	46.5	374	21.6	464	21.4
Phosphate rock (hard)	12,387	90.1	10,965	74.1	12,737	86.7	13,575	90.9
Phosphate rock (fertilizer)	(a)	8.9	(a)	8.9	(a)	9.5	(a)	11.9
Normal superphosphate	37	1.3	37	.9	18	.6	14	.3
Concentrated superphosphate	1,089	46.1	711	26.2	627	23.0	924	33.1
Ammonium phosphate	970	57.6	986	53.5	1,135	59.4	1,542	91.6
Potassium chloride	1,057	26.0	902	23.7	772	22.4	859	28.1
Potassic chemical fertilizer	233	.2	186	7.3	238	9.5	211	9.2
Sodium nitrate		.1		--		--		--
Fertilizer materials	269	19.8	404	26.0	317	24.0	243	27.4

1/ Short tons of product.

(a) Tonnage included in Phosphate Rock (hard).

Source: Fertilizer Situation, No. FS3, ERS, USDA, Washington, D. C., December, 1972, pp. 20, 21.

Table III-8. U.S. exports of selected and total nitrogen fertilizers

Year	Anhydrous Ammonia	Ammonium Nitrate	Ammonium Sulfate	Urea	Other	Total
			(000 tons of nitrogen)			
1964	84	29	102	17	NA	264[c]
1965	98	34	202	15	NA	392[c]
1966	141	29	338	33	NA	546[c]
1967	323	14	220	42	NA	749[c]
1968	590	29	293	207	NA	1, 045[c]
1969	703	37	162	268	NA	1, 594[c]
1969-1970[a]	628	27	111	309	253	1, 328
1970-1971	491	20	126	172	268	1, 077
1971-1972	346	11	117	214	344	1, 032
1972-1973[b]	469	5	92	244	449	1, 259

[a] Calendar years through 1969, fiscal years thereafter, 1969-70 data from The Fertilizer Supply, 1971-72, ASCS, USDA, Washington, D. C., April 1972, 1970-71 and following years data from The Fertilizer Supply, 1972-73, April 1973.

[b] Estimated

[c] Fiscal year ending in indicated year.

Source: Fertilizer Trends, no. y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, December 1971.

Table III-9. U.S. exports of selected and total phosphate fertilizers

Year	Superphosphate Exports		Ammonium Phosphates[a]	Other	Total
	Normal	Concentrated	(000 Tons of P_2O_5)		
1964	39	276	127	NA	400[d]
1965	17	233	112	NA	432[d]
1966	18	294	270	NA	441[d]
1967	15	291	445	NA	787[d]
1968	19	533	445	NA	1,145[d]
1969	6	361	330	NA	995[d]
1969-1970[b]	7	327	441	70	845
1970-1971	4	288	507	99	898
1971-1972	3	333	689	77	1,102
1972-1973[c]	7	473	916	103	1,499

[a] Estimated average analysis 15-33-0.

[b] Calendar years through 1969, fiscal years thereafter. 1969-1970 and following years data from The Fertilizer Supply, 1971-72, ASCS, USDA, Washington, D. C., April 1972 and 1972-73, April 1973.

[c] Estimated

[d] Fiscal year ending in indicated year.

Source: Fertilizer Trends, 1971, no. y-40, Tennessee Valley Authority,
Muscle Shoals, Alabama, December 1971.

The export of primary plant nutrients rose about 8 percent in 1971-72 to 2.8 million tons, compared to 2.6 million tons in 1970-71, after having declined by about 10 percent in 1969-70. Nitrogen on a nutrients basis declined slightly: phosphorous content of exports rose by 23 percent and potash by 6 percent.

Among nitrogen fertilizers, anhydrous ammonia accounted for 34 percent and urea for 21 percent of the nitrogen exported in 1971-72 (Table III-8).

For phosphate fertilizers, ammonium phosphates furnished 63 percent and concentrated superphosphates 30 percent of total P_2O_5 exports in 1971-72 (Table III-9).

Fertilizer exports must be viewed alongside imports. In 1971-72 the United States imported 7.9 million tons of fertilizer materials. Most of the tonnage came from Canada, consisting mainly of potassium chloride. The U.S. bought 4.9 million tons of potassium chloride from Canada, which was 62 percent of all fertilizer imports. Table III-10 lists imports of selected materials for 1967 through 1972.

The United States, in terms of primary nutrient, is currently a net exporter of nitrogen and phosphates. (See Table III-11.) In terms of products, the U. S. is currently a net importer of only ammonium nitrate.

Industrial and Governmental Markets

Seventy-five percent of all nitrogen production was consumed in fertilizers in 1971, with industrial consumption accounting for the rest of the output.[1] The use of nitrates in explosives, as one segment of industrial consumption represents the only substantial area of government purchases. With the cessation of bombing in Indo-China, this demand could drop sharply, reducing the overall industrial demand for nitrogen materials. Such a change could have the net effect of depressing nitrogen prices in the agricultural sector. Industrial uses of wet process phosphorous and potash are a minor component of the total market for each product. The major direct government market of fertilizer products is the U.S. Agency for International Development (AID) export finance program. Until 1966, the U.S. had always been a net importer of nitrogen (N), excepting 1947-1949. The net exporting position since 1965 (and 1947-49) has resulted from the emphasis of AID programs on fertilizer use in their development programs. Since 1941, the U.S. has been a net exporter of phosphate materials, but with the AID requirements, their P_2O_5 position was improved.

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[1] Harre, E. A., "Trends in the Supply-Demand Situation," Searching the Seventies, Proceedings of the Fertilizer Production and Marketing Conference, Memphis, Tennessee, September 15-17, 1971, No. y-34, Tennessee Valley Authority, Muscle Shoals, Alabama, September 1971, pp. 10-11.

Table III-10. U.S. imports of selected fertilizer materials, 1967-1972

Material	1966-1967	1967-1968	1968-1969	1969-1970	1970-1971	1971-1972
			-----Short tons of material-----			
Anhydrous ammonia	392,502	420,125	425,103	477,189	501,451	392,975
Ammonium nitrate	174,274	219,529	234,528	306,010	365,943	390,324
Ammonium nitrate-limestone	1,480	6,849	1,265	62	134	
Ammonium sulfate	170,581	143,155	134,979	179,350	218,752	263,559
Sodium nitrate	270,783	195,495	159,875	164,130	188,207	159,500
Calcium nitrate	48,832	32,629	50,884	48,747	48,293	39,314
Urea	275,157	241,154	251,057	423,577	329,640	365,218
Calcium cyanamide	19,749	16,979	15,152	10,862	8,357	3,356
Nitrogen solutions	82,472	69,742	80,841	97,651	194,494	119,540
Synthetic nitrogenous material	21,445	15,944	15,818	13,112	12,661	35,438
Phosphate, crude	168,801	127,650	114,019	153,626	123,194	67,058
Ammonium phosphate	193,984	224,497	277,072	395,476	471,779	488,865
Potassium chloride	2,578,189	3,608,238	3,175,006	4,377,755	4,115,291	5,082,283
Potassium sulfate	60,716	49,444	40,134	69,717	62,732	48,042
Potassium-sodium nitrate	50,603	28,959	32,821	39,094	74,913	39,586
Mixed fertilizers	175,133	178,738	161,080	168,668	198,307	188,473

Source: The Fertilizer Supply, 1971-72, ACSC, USDA, Washington, D.C., April 1972, p. 14, and The Fertilizer Supply, 1972-73, April 1973, p. 14.

Table III-11. U.S. imports and exports of primary plant nutrients, 1951-52 through 1972-73

Fertilizer Year	N		P_2O_5		K_2O	
	Imports	Exports	Imports	Exports	Imports	Exports
	1,000 tons					
1951-52	290	73	39	94	264	63
1952-53	429	44	41	74	159	54
1953-54	421	62	62	88	121	54
1954-55	373	141	61	154	139	91
1955-56	330	255	56	153	170	180
1956-57	294	268	54	256	179	315
1957-58	305	227	59	246	213	252
1958-59	294	223	64	204	238	310
1959-60	298	188	82	177	282	418
1960-61	276	213	67	238	285	484
1961-62	337	234	87	283	282	503
1962-63	344	196	117	275	486	411
1963-64	453	264	100	400	691	526
1964-65	470	392	98	432	884	625
1965-66	529	546	125	441	1,332	664
1966-67	669	749	165	787	1,643	678
1967-68	675	1,045	169	1,145	2,225	714
1968-69	690	1,594	183	995	1,944	798
1969-70	855	1,328	273	845	2,646	681
1970-71	929	1,077	283	898	2,510	620
1971-72	843	1,032	326	1,102	3,088	657
1972-73*	971	1,259	373	1,499	2,857	866

*Estimated

Source: Fertilizer Supply, ASCS, USDA, Washington, D. C., April 1973, p. 18.

However, exports financed by AID are declining as AID has reduced its emphasis on this program. Also, the requirement that 50 percent of the AID financed fertilizer go on U.S. flag ships makes it difficult for U.S. sellers to compete with development programs in other countries. As a result, the importance of AID financed fertilizer has declined since a peak in 1967-1968. As shown in Table III-12, AID exports amounted to only 11 percent of total export value, down from 20 percent in 1970. This compares to about 40 percent in 1967-68.

AID financed exports include ten of the popular fertilizers. The single largest product, in absolute and relative terms, is urea which is dominated by AID (Table III-12). Mixed fertilizers and ammonium phosphates are the second and third most important products in the AID program.

Demand Projections

Continued growth of food and fiber demands will increase the demand for fertilizers in agricultural production. Recent surges in exports of agricultural commodities have raised agricultural prices and is stimulating production. Cropland in production is estimated to increase 25 million acres in 1973. Foreign demand increase resulted from poor crop years in various countries and from low production of fish meal in South America. For projection purposes much of this recent increase in prices and exports is considered a short run phenomena, and is not expected to continue at the same level through the projection period. A portion of this increase in agricultural exports is assumed to continue during the projection period.

Fertilizer rates on crop acres already receiving fertilizer are showing declining rates of increase and in some cases appear to have stabilized. Nitrogen appears to have the greatest potential for increased application rates. For the major crops receiving fertilizer applications, the proportion of total acres receiving fertilizer is nearing the maximum. Use of fertilizer on soybeans is least wide spread with only 28 percent receiving fertilizer. With rates stabilizing and proportion of crop acres covered reaching maximum, the major increases in demand for fertilizers will be from increases in lands cropped. Projected percentage annual rates of increase in consumption of three plant nutrients are 5, 3, and 4, for nitrogen, P_2O_5 and K_2O, respectively. These rates are lower than the average annual rates of increase for the previous 10 years. Annual rates were reduced to the above levels for the reasons given above. This is further supported by the fact that average annual rates of increase appear to be declining.

Table III-12. Relationship of AID financed exports to total U.S. exports, 1970-1972

	1970			1971			1972		
		AID financed			AID financed			AID financed	
	Total	Value	Percent	Total	Value	Percent	Total	Value	Percent
	(million $)	(000)		(million $)	(000)		(million $)	(000)	
Ammonium sulfate	$ 16.0	$ 1,607	10	$ 9.2	$ 469	5	$ 9.8	$ 395	4
Ammonium phosphate	53.5		20	59.4	37	10	91.6	20	--
Diammonium phosphate		10,620			5,956			16,944	19
Urea	46.5	28,802	64	21.6	15,508	72	21.4	14,829	69
Triple superphosphate	26.2	3,153	12	23.0	1,770	8	33.1	3,117	9
Potassium chloride	23.7	379	2	22.4	264	1	28.1	241	1
Potassium sulfate	1/	472	NA	1/	589	NA	1/	546	NA
Mixed fertilizer	26.0	16,497	63	24.0	8,097	34	27.4	12,344	45
Anhydrous ammonia	21.7	--	0	19.7	364	2	13.2	431	3
Sulfate of potash-magnesia	1/	--	0	1/	36	NA	--	--	--
Other	95.3	--	0	109.3	--	0	--	--	--
Total	$308.9	$62,584	20	$288.6	$33,090	11	$338.9	$48,867	14

1/ Included in "other"

Source: Fertilizer Situation, no. FS2, ERS, USDA, Washington, D. C., January, 1972 and no. FS3, December, 1972.

Berry evaluated U.S. food production as it relates to world needs, determined the amount of fertilizer required to meet agricultural experiment station recommendations for various crops, and then estimated how rapidly farm use would approach those levels.[1] His conclusion was that annual growth rates would decrease during the 1970's. For the period 1970 to 1980, he estimated growth rates of 5, 3, and 3 percent for nitrogen, P_2O_5, and K_2O, respectively. These estimates correspond closely with the estimates above.

Projected U.S. fertilizer consumption for the three plant nutrients are shown in Table III-13. The average consumption for the years 1969 to 1973 were used as 1971 base point for making the projections. Nitrogen fertilizer consumption is expected to increase from 8.7 million tons in 1973 to 12.7 million tons in 1980, P_2O_5 fertilizer consumption from 5.1 million tons to 6.3 million tons, and K_2O fertilizer consumption from 4.9 million tons to 6 million tons. These projections assume no major changes in the price relationships among fertilizers.

Total U.S. ammonia requirements to meet demands are shown in Table III-14. Domestic nitrogen fertilizer consumption projections are obtained from Table III-13 above. Industrial nitrogen consumption is broken into two parts for projection purposes - synthetic fiber production and other uses. Nitrogen consumption for synthetic fiber production is assumed to increase 10 percent annually. Other industrial uses of nitrogen should increase at the same rate as industrial production. This demand is assumed to increase 3.5 percent annually. Total industrial consumption (Table III-14) is projected to increase from 3.16 million tons in 1972 to 4.82 million tons in 1980.

U.S. trade position for nitrogen changed with the construction of new low cost ammonia plants incorporating centrifugal compressors. The drastically reduced costs associated with the new technology encouraged construction of new capacity and the eventual over capacity in the industry (73 percent utilization from 1968-1970). Wholesale ammonia prices dropped from $78 per ton in 1966 to $36 per ton in 1970 (54 percent drop in price) and the U.S. trade in nitrogen reversed itself. Plant utilization is nearing full capacity and is projected to exceed full capacity by mid-1970's. When all U.S. capacity will be required to meet U.S. consumption requirements, net exports will fall to zero. Total ammonia requirements (based on 82 percent nitrogen content) to meet demands in 1972 was 13,820,000 tons. This is projected to increase to 21,300,000 tons by 1980. Production to meet this requirement (including allowance for a 3.5 percent loss in production processes) is projected to increase from 14.3 million tons in 1972 to 22.1 million tons in 1980.

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[1] Berry, John H., "A Comparison of Projections of Fertilizer Use by 1980", Fertilizer Situation, March 1971, U.S.D.A., ERS.

Table III-13. Projected U.S. consumption of primary plant nutrients, 1973-1980.

Year	Nitrogen	P_2O_5	K_2O
		(000 short tons)	
1973	8,719	5,117	4,584
1974	9,198	5,270	4,767
1975	9,704	5,430	4,960
1976	10,238	5,593	5,156
1977	10,800	5,760	5,360
1978	11,400	5,930	5,600
1979	12,000	6,110	5,800
1980	12,700	6,290	6,000

Projections based on 5.5 percent annual increase in nitrogen consumption, 3 percent annual increase in phosphorous consumption, and 4 percent annual increase in potash consumption. Projections made by DPRA.

Table III-14. Actual and projected U.S. nitrogen consumption and required NH_3 production, 1967-1972 with projections to 1980

Fertilizer Year	Domestic fertilizer consumption	Industrial consumption	Total consumption	Net Import/export	Total ammonia requirements
			(000 short tons)		
1967	6,026	2,747	8,773	-80	10,760
1968	6,693	2,600	9,293	-370	11,750
1969	6,957	2,730	9,687	-904	12,900
1970	7,459	2,870	10,329	-473	13,130
1971	8,133	3,000	11,133	-148	13,700
1972	8,016	3,160	11,176	-189	13,820
Projected					
1973	8,700	3,320	12,020	-0-	14,600
1974	9,200	3,500	12,700	-0-	15,440
1975	9,700	3,690	13,390	-0-	16,280
1976	10,200	3,880	14,080	-0-	17,120
1977	10,800	4,090	14,890	-0-	18,100
1978	11,400	4,320	15,720	-0-	19,100
1979	12,000	4,560	16,560	-0-	20,100
1980	12,700	4,820	17,520		21,300

Source: 1967-1972 consumption data from Fertilizer Trends 1973 (and earlier), No. Y-77, Tennessee Valley Authority, Muscle Shoals, Projections by DPRA.

World P_2O_5 consumption is projected to increase 5 percent annually to 33.3 million metric tons in 1980 (TableIII-15). World trade in P_2O_5 was 12.2 percent of world consumption in 1966 and increased to 16.9 percent of world consumption in 1968. Subsequently this figure has dropped to about 15 percent. Projections of world trade in P_2O_5 assume world trade at 15 percent of world consumption. U. S. share of world trade in P_2O_5 increased slowly from 22.2 percent in 1966. Following the introduction of wet process P_2O_5 plants in 1966 and subsequent years capacity expansion exceeded consumption. Wholesale price of P_2O_5 dropped and U.S. exports increased to 36.5 percent of world trade. It has since declined to 33.7 percent in 1973. U.S. exports are projected to decline to 28 percent of world trade by 1980. U.S. P_2O_5 exports for 1980 are projected at 1.4 million metric tons.

Total change in consumption of P_2O_5 in the U. S. from 1972 to 1980 is projected to be 1,857 million tons (Table III-16). This projection is based on a 1.417 million tons increase in domestic production and a .44 million tons increase in U. S. exports.

World potash consumption is projected to increase to 27.3 million tons in 1980. U. S. consumption is projected to increase to 5.44 million tons in 1980. U. S. consumption as a percent of world consumption is falling (from 23.6 percent in 1973 to 19.9 percent in 1980) because world consumption is growing faster than U. S. consumption (Table III-17).

2. Supply

Technological Change in Fertilizer Industry

The current technology for the fertilizer industry, described under production processes in Chapter I, Section B, can be generally evaluated as advanced. No revolutionary new technologies have been announced for the immediate future. Predictably, existing technology will be adopted increasingly by producers with older, smaller plants which are replaced or rebuilt. This will be especially true in ammonia production, where the centrifugal compressor was introduced in the mid-1960's.

Compression of gases is vital to ammonia production since in some of the processes the pressure of synthesis gases must be raised to 2,000 to 5,000 psig for reaction. The introduction to the ammonia industry of single unit centrifugal compressors (steam turbine driven) revolutionized production conditions. Prior to this, compression was achieved through use of multi-stage reciprocal compressors driven by electric

Table III-15. World consumption, world trade, and U.S. exports of P_2O_5, 1961-1973 with projections to 1980

Year	World P_2O_5 consumption (1,000 metric tons)	World P_2O_5 Exports (1,000 metric tons)	World P_2O_5 Exports % of consumption	U.S. P_2O_5 Exports (1,000 metric tons)	U.S. P_2O_5 Exports % world exports
1961	9,970	1,210	12.1	209	17.3
1962	10,430	1,383	13.3	256	18.5
1963	11,100	1,428	12.9	250	17.5
1964	12,230	1,635	13.4	363	22.2
1965	13,580	1,672	12.3	392	23.4
1966	14,772	1,802	12.2	400	22.2
1967	15,998	2,266	14.2	713	31.5
1968	16,878	2,845	16.9	1,039	36.5
1969	17,995	2,892	16.1	902	31.2
1970	18,617	2,717	14.6	767	28.2
1971	19,788	2,759	13.9	775	28.1
1972	22,375	3,130 1/	14.0 1/	1,000 1/	31.9 1/
1973	23,700 1/	3,560 1/	15.0 1/	1,200 1/	33.7 1/
Projected					
1974	24,900	3,735	15.0	1,100	29
1975	26,100	3,900	15.0	1,000	26
1976	27,500	4,120	15.0	1,100	27
1977	28,800	4,320	15.0	1,200	28
1978	30,300	4,550	15.0	1,250	28
1979	31,800	4,700	15.0	1,300	28
1980	33,300	5,000	15.0	1,400	28

1/ Estimated

Projections by DPRA. World consumption projections based on 5% annual growth rate, world export at 15% of world consumption and U.S. exports declining and then stabilizing at 28% world exports.

Sources: Years 1960/61 through 1970/71 from Annual Fertilizer Review (1966 and 1971), Food and Agriculture Organization of the United Nations.

Years 1972 and 1973 estimated by DPRA to reflect existing supply and market conditions.

Years 1974-1980 projected by DPRA to reflect a return to normally historic conditions and ancitipated trends. World consumption projected to grow at an annual rate of 5 percent compared to 7.4 percent annually over previous 7-year period.

Table III-16. Changes in consumption and export of P_2O_5, projections for 1973-1980

Year	Increase in U.S. exports[1]	Increase in domestic consumption[2]	Net change, domestic consumption and exports	Projected P_2O_5 consumption
		(000 tons)		
1973	220	244	464	5,914
1974	(110)	153	43	5,957
1975	(110)	160	50	6,007
1976	110	163	273	6,280
1977	110	167	277	6,557
1978	55	170	225	6,782
1979	55	180	235	7,017
1980	110	180	290	7,307
Total Increase	440	1,417	1,857	-

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[1] Net annual change in column 2, Table

[2] Net annual change in column 4, Table
Estimated that at future P_2O_5 fertilizer growth filled by wet-process P_2O_5 derived products.

Table III-17. World and U.S. K_2O consumption, 1961-1972 with projections to 1980

Year	World	U.S.	U.S. % of world
	(000 metric tons)		
1960/61	8,500	1,967	23.1
1962	8,670	2,060	23.8
1963	9,280	2,271	24.5
1964	10,020	2,476	24.7
1965	10,990	2,566	23.3
1966	12,090	2,922	24.2
1967	12,982	3,304	25.4
1968	13,955	3,441	24.7
1969	14,636	3,530	24.1
1970	15,449	3,661	23.7
1971	16,522	3,839	23.2
1972	17,100	3,931	23.0
Projected			
1973	18,100	4,264	23.6
1974	19,200	4,330	22.6
1975	20,400	4,500	22.1
1976	21,600	4,680	21.6
1977	22,900	4,860	21.2
1978	24,300	5,080	20.9
1979	25,800	5,260	20.4
1980	27,300	5,440	19.9

Source: 1960/61 through 1971 from Annual Fertilizer Review (1966 and 1971), Food and Agricultural Organization of the United Nations, Projections by DPRA.

motors or gas engines. The centrifugal compressor was decidedly more efficient, but in order for these efficiencies to be achieved, it had to be geared for use in an ammonia plant with capacities in excess of 600 tons per day. Typical plant sizes up to 1965 were 150, 300 and 400 tons per day.

Similarly, in phosphate production, further conversion from orthophosphate to polyphosphate forms can be expected. This development permitted the increased use of liquid materials in the 1960's.

The current technology is adequate for meeting market demands, both current and projected. Barring unforeseen drastic changes in the demand picture, the current technology will not only be adequate but will be adaptable to larger scale units, especially in the ammonia and wet phosphoric acid segments of the industry.

Capacity and Capacity Utilization

The fertilizer industry has recently emerged from a period of severe overcapacity in basic ammonia and phosphoric acid. Capacity utilization of these two primary products reached low points of 73 percent and 69 percent respectively in 1969 (see Table III-18). This was the result of a rapid buildup of capacity for both ammonia and phosphoric acid which began in 1965.

Spurred by the anticipated economies (absolute savings in power costs) of production inherent in the use of centrifugal compressors --discussed in the preceding section on technology--and also by the economies inherent in large scale operations, the industry rapidly adopted this new technology. The result was severe overcapacity and ultimate closure of many smaller plants because of price deterioration.

In the phosphate area, the industry simply overbuilt because of a rosy outlook. The newer plants, however, were vastly larger than the traditional production unit. Here, too, overcapacity resulted in price deterioration and forced closure of many smaller production units.

Presently, operating rates for ammonia and phosphoric acid are at 89 percent and 93 percent, respectively. Conditions are expected to further improve in ammonia (price increases expected) and some major capacity increases are required (beyond what has been indicated after 1973 in Table III-18.) However, because of the inability of prospective producers to secure natural gas supplies (due to gas shortage) expansion plans virtually have come to a standstill.

Table III-18. Production vs. capacity - United States indicated and projected, 1965-1980

	Anhydrous Ammonia			Wet Process Phosphoric Acid		
	Capacity	Production	Percent	Capacity	Production	Percent
		-million tons-			-1000 tons P_2O_5	
1965	8.6	8.9	103	2900	2895	100
1966	11.0	10.6	96	3879	3596	92
1967	13.4	12.2	89	5012	3993	80
1968	16.6	12.1	73	5392	4152	77
1969	17.5	12.8	73	6232	4328	69
1970	18.8	13.8	73	5532	4642	84
1971	17.0	14.0	82	5532	5286	96
1972	16.9	14.3	85	5652	5450	96
1973	16.9	15.1	89	6370	5914	95
1974	17.4	16.0	92	7137	5957	84
1975	17.9	16.9	94	8757	6007	69
1976	17.9	17.7	99	8757	6280	72
1977	17.9	18.7	(104)	8757	6557	75
1978	17.9	19.8	(111)	8757	6782	77
1979	17.9	20.8	(116)	8757	7017	80
1980	17.9	22.1	(123)	8757	7307	83

Source: Developed by DPRA from a variety of published and unpublished data collected over a period of years.

Currently, the phosphate chemical industry is enjoying a boom. As a result of recent price increases, prospective returns on investments have reached favorable levels for P_2O_5 products. Aggressive expansion plans for phosphoric acid production already have been announced - an increase of almost 40 percent over current levels.[1] If these plans come to fruition, indicated phosphoric acid operating rates should drop to a low of 69 percent by 1975. Therefore, price outlook for 1975-1979 appears imminently unfavorable.

Capacity utilization for end-products is sketchy, but some operating rates for selected materials can be developed by piecing together available trend information from TVA with DPRA estimates of current capacity.

Ammonium Nitrate - At present there are 54 ammonium nitrate plants in the U.S. with a total annual capacity of 7,192,000 short tons of product. Production has increased over five-fold in the last twenty years--about 8.5 percent annually, compounded growth rate (see Table III-19). Growth in recent years, however, has leveled off considerably because of inroads made by urea in competition for similar markets.

Urea - There are presently 42 urea plants in the U. S. with a total capacity of 4,363,000 short tons of product. Production has increased four-fold during the last ten years--about 15 percent annually, compounded growth rate. (See Table III-20.)

Ammonium phosphate - There are 41 (di)ammonium phosphate plants in the U.S. with a total capacity of 3,681,000 tons of P_2O_5 equivalent (all grades). Production of ammonium phosphate (including diammonium phosphate--most production units can interchange among grades) has increased dramatically over the last dozen years--almost eight fold (See Table III-22).

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[1] Based upon a special survey of companies on announced construction in the phosphate industry. This survey was conducted in 1972 and updated in 1973 by Malk Associates.

Table III-19. Total ammonium nitrate capacity utilization, 1950-1977 1/

Year	Production	Capacity	Percent
1950	1,214	NA	NA
1955	2.078	NA	NA
1960	3,122	NA	NA
1965	4,663	NA	NA
1966	5,117	NA	NA
1967	6,005	6,954	86
1968	5,737	7,297	79
1969	5,891	7,474	79
1970	6,456	7,491	86
1971	6,605	7,400	89
1972	6,872	7,432	92
1973	7,150	7,200	99
1974	7,430	7,200	103
1975	7,730	7,460	104
1976	8,040	7,460	10[illegible]
1977	8,360	7,460	112

1/ Approximately one-half is solid fertilizer grade ammonium nitrate.

2/ Projected production at 4 percent annual growth rate.

Source: TVA, Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Ala., December 1971 and Current Industrial Reports, Inorganic Chemicals, 1971, no. M28A(71)-4, U.S. Dept. of Commerce, Bur. of the Census, Wash., D.C., Oct., 1972.

Table III-20. Urea production, 1960-1972 (1,000 tons)

Year	Total Primary Solution	Fertilizer			Other	
		Solution	Solid	Total	Feed Grade	Industrial
1960	747	247	302	548	95	91
1961	915	313	421	734	102	86
1962	1,029	342	466	808	111	91
1963	1,106	276	479	854	126	111
1964	1,244	435	546	981	119	109
1965	1,400	472	546	1,018	150	118
1966	1,768	666	693	1,359	193	164
1967	2,180	825	876	1,700	231	160
1968	2,436	996	985	1,981	282	172
1969	2,976	1,105	1,351	2,457	335	180
1970	3,119	NA	NA	2,611	336	172
1971	2,820	NA	NA	NA	NA	NA
1972	3,724	NA	NA	NA	NA	NA

Source: TVA, Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Ala., December 1971 and Current Industrial Reports, Inorganic Chemicals, 1971, No. M28A(71)-4, U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C., October, 1972.

Table III-21. Total urea capacity utilization, 1965-1977
(1,000 tons)

Year	Production	Capacity	Percent
1965	1,400	NA	NA
1966	1,768	NA	NA
1967	2,180	3,032	72
1968	2,436	3,262	75
1969	2,976	3,948	75
1970	3,119	4,369	71
1971	2,820 1/	4,538	62
1972	3,724 1/	4,462	83
1973	4,100 2/	4,362	94
1974	4,400	5,100	86
1975	4,800	5,315	90
1976	5,200	5,315	98
1977	5,700	5,315	107

Source: Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Ala., Dec. 1971 and Estimated World Fertilizer Production Capacity as Related to Future Demand, No. Y-48, Tennessee Valley Authority, August, 1972.

1/ Current Industrial Reports, Inorganic Fertilizer Materials, M28B(71)-13, M28B(72)-1 through 12, U.S. Dept. of Commerce, Bureau of the Census, Washington, D.C.

2/ Projected at 9 percent annual growth rate, 1972-1977

Table III-22. Ammonium phosphate capacity utilization, 1950-1977
(1,000 tons P_2O_5)

Year	Production			Capacity[2]	Percent
	Ammonium phosphate	Other	Total[1]		
1950	--		11		
1955	--		8		
1960	269	131	400		
1965	1,081	172	1,253	1,729	72
1966	1,376	239	1,615	2,545	63
1967	1,747	284	2,031	3,073	66
1968	1,633	215	1,848	3,326	56
1969	1,844	288	2,132	3,913	54
1970	2,070	361	2,431	3,100	78
1971	2,395	468	2,863	2,900	99
1972	2,569	570	3,139	3,355	94
1973			3,500	3,681[4]	95
1974			3,550[3]	4,300[4]	83
1975			3,600[3]	5,500[4]	65
1976			3,800	5,500[4]	69
1977			4,000	5,500[4]	73

[1] Projected annual growth rates which reflect lower future total fertilizer P_2O_5 growth rates. Future fertilizer P_2O_5 consumption in the U.S. projected at 3.5 percent annually.

[2] Capacity data - Malk Associates files

[3] Assumes return to lower level export requirements compared to previous years.

[4] Assumes 75 percent of new phosphoric acid capacity will be directed toward ammonium phosphates.

Source: Production data, Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Ala., December, 1971.

Growth in recent years has been equally impressive--in the range of 10 to 18 percent annually. These products are high analysis types, relatively low cost and enjoyed rapid growth through displacement of lower analysis types like normal superphosphate. A recent surge in exports also contributed to their rapid growth. However, saturation levels have been attained and future growth is expected to approximate the lower total growth rates of all fertilizer P_2O_5. It is anticipated that 75 percent of expected new phosphoric acid capacity will be directed toward ammonium phosphate production. This is based on the industry facilities survey conducted by Malk Associates in 1972 and 1973.

Triple superphosphate - There are thirteen producers of triple superphosphate at 15 plant sites. Production capacity is 1,882,000 tons of P_2O_5. Production had increased rapidly during the early sixties but peaked out in 1966, the result of partial displacement by the heavily demanded diammonium phosphate. (See Table III-23.)

Normal superphosphates - It is estimated that there are only 60 normal superphosphate plants in the U.S. reporting any production in 1973 compared to a high of over 200 in 1955. Normal superphosphate is a low analysis product which has experienced steadily decreasing demand over the years--the result of displacement by the more popular high analysis P_2O_5 products such as diammonium phosphate. (See Table III-24.)

3. Pricing

An examination of pricing practices in the fertilizer industry produces an impression of a lack of controllable standards. Standard levels of gross margins do not exist to assure the operation of long-term, viable production and retailing functions. Even credit charges and service fees vary from company to company and from area to area and discount practices, it seems, abound according to each company's individual formula. This unstable situation reflects the competitive nature of the industry, characterized by a lack of price leadership, a changing configuration in distribution, new processes and production technology and periodic supply-demand imbalances at both retail and wholesale levels.

Table III-23. Triple superphosphate capacity utilization, 1950-1977
(1,000 tons P_2O_5)

Year	Production	Capacity[1]	Percent
1950	309		
1955	707		
1960	986		
1965	1,466	1,300	100
1966	1,696	1,603	100
1967	1,481	2,190	68
1968	1,389	2,300	60
1969	1,354	1,750	77
1970	1,395	1,750	80
1971	1,503	1,750	86
1972	1,650	1,750	94
1973		1,882	
1977	1,800[2]	1,882	96

[1] Capacity data, Malk Associates files.

[2] Projected to only reach present capacity operations - industry is in transitional state and not expected to show further growth.

Source: Production data, Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Ala., December, 1971.

Table III-24. Normal superphosphate production, 1955-1977
(1,000 tons P_2O_5)

Year	Production	Number of Plants Reporting	Capacity
	1,673	200	
1955	1,558	200+	
1960	1,270		
1965	1,113	170	
1966	1,138		
1967	1,184		
1968	914		
1969	807		
1970 [2/]	626	80	
1971	678		
1972	678		
1973	671		
1975	600	60	735
1977	500 [1/]	50 [1/]	

[1/] Projected by DPRA.

[2/] The Fertilizer Supply, U. S. Dept. of Agriculture, Washington, D. C., April, 1973, for 1970-73 data.

Source: Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Ala., December, 1971.

Market Structure

The 109 firms engaged in the production of the basic chemicals for fertilizers are dominated by large, integrated, diversified companies, some of which are international in scope. These firms are essentially chemical manufacturers (i.e., Allied Chemical Co., E. I. Dupont de Nemours, Hercules, Inc., Monsanto Co., Borden Chemical Co., Olin Corporation) or petrochemical companies (i.e., American Oil Co., Phillips Petroleum Co., Gulf Oil Co.).

The first distinguishing characteristics of these firms is their high degree of deversification. For these companies, fertilizer sales, as a percent of gross sales, may be relatively small. For example, Allied Chemical Co., the largest producer of ammonia, realized only 8 percent of its gross revenues from fertilizer sales in 1971.

Another characteristic of these large producers is their operation of multiple plants with multiple products at a single location. This horizontal integration is reflected in the fact that 84.7 percent of basic product plants are a part of a multiplant complex.

These same companies may be vertically integrated, both backward to raw material production and forward to the manufacture of mixed fertilizers and/or the retail distribution of fertilizers to the farmer-user. Data are not available to identify precisely those firms which are vertically integrated; among the largest basic producers, however, there is widespread backward integration. There is less forward integration into retail distribution than previously, with basic producers now accounting for approximately 25 percent of all retail sales through their own outlets.

The extent to which these integrated, diversified companies dominate the basic production segment of the industry is partially obscured by the fact that many smaller but important producing companies are operating subsidiaries of the larger companies. In many instances, the operating company has retained its corporate name, even though it has been integrated with the parent company from an operations viewpoint. This is an important consideration in evaluating the impact of increased costs resulting from pollution abatement. Whether or not a given plant may close as a result of increased costs will depend in many cases on the role of that plant in the total corporate strategy.

In addition to the large, integrated, diversified companies, there are three other types of firms engaged in basic production of fertilizer chemicals. These are (1) the cooperatives, which are also generally integrated and diversified; (2) the smaller chemical companies which have one or two locations and produce only one or two products; and (3) manufacturers of unrelated products (i.e., steel) who have by-product chemicals which move into fertilizer production. These groups account for a relatively small amount of total capacity.

Fertilizer moves from the mines and basic plants to farmers through a rather complex set of alternative distribution avenues. The most involved avenue follows the steps below:

- Shipment to independent mixers and/or distributors
- Processing by mixers
- Shipment to dealers
- Delivery to farmers

The least involved avenue is distribution directly from the basic fertilizer production plant directly to the consumer. However, generally the product will have to move to a retail outlet. Figure III-4 is a simple diagram of the domestic distribution system.

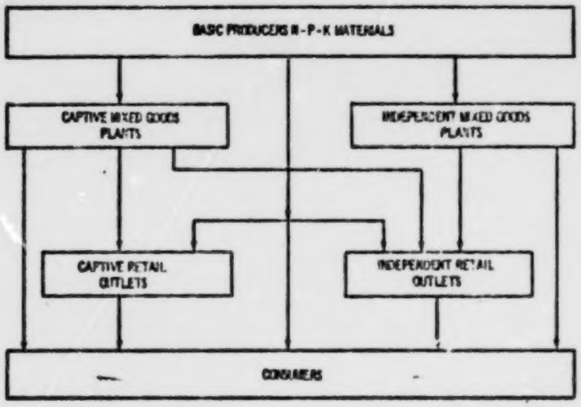
BASIC PRODUCERS N-P-K MATERIALS
CAPTIVE MIXED GOODS PLANTS
INDEPENDENT MIXED GOODS PLANTS
CAPTIVE RETAIL OUTLETS
INDEPENDENT RETAIL OUTLETS
CONSUMERS

Figure III-4. Domestic fertilizer distribution channels

As shown in Figure III-4, the channels are identified as either captive or independent. The captive units are those owned by cooperative and investor basic producers. Independent outlets on the other hand are owned by firms without a basic production position. Investor owned firms have tended to integrate forward from basic production to mixing to retailing whereas the cooperatives have tended to integrate backward from retail outlets. Integration has been quite prevalent since 1950. Currently, at the retail level, distribution to the farmer is divided among independent retailers (38 percent), cooperatives (37 percent) and investor owned national producers' outlets (25 percent). [1] The independents and cooperatives tend toward farm service stores, with diversified farm product lines, while the investor owned nationals tend more toward specialization.

Prior to the 1950's, most fertilizer reached the customer through a nonintegrated channel--raw material producers sold to mixing plants which sold to retail dealers who sold to farmers. Most of the product was produced in local dry mixing plants and sold in bags.

The late 1950's and early 1960's saw profound changes in distribution, resulting largely from new technology in manufacturing. The spread of the TVA ammoniator-granulator process after 1953 led to the building of regional granulator plants for diammonium phosphates. This brought on the use of bulk fertilizers and saw the local dry mixing plants replaced by local dry bulk blend plants. Simultaneously, the number of liquid blending plants increased rapidly as synthetic ammonia production rose sharply in the 1960's.

The trend has been toward a more economic movement of fertilizer materials from the producer to the farmer-user. Granulator plants, bulk blending plants, liquid mixed plants, farm service centers and specialized retail outlets were established in unprecedented numbers in the 1960's. Large-scale production plants contributed greatly to the opening of a great many retail outlets as producers feared they could not move their output through non-captive outlets. Many of these outlets have either closed or have been purchased by cooperatives or independents. Also, the advent of bulk blending and liquid mixing limited the distribution area, because the specialized spreading equipment could not be tied up too long for trips from the supply center to the farm. This contributed to the rapid growth in number of plants in the 1960's.

The most dramatic change has been the shift from dry bagged fertilizers to dry bulk fertilizers. In 1960, 15 percent of the dry fertilizer was sold in bulk. By 1970, this had increased to 50 percent (Table III-25). This development has been accompanied by a phenomenal increase in bulk blending units, increasing from 201 in 1959 to 5, 158 in 1970. This development has been pronounced in the North Central region which contains 70 percent of all bulk blend plants in the United States. [2] (Table III-26.)

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[1] Henderson, C. M., "Change in Retail Marketing," Agricultural Chemical Marketing in the Changing '70's, Proceedings, Chemical Marketing Research Association, Atlanta, Ga., 1972.

[2] Bulk blend plants normally are synonymous with retail outlets.

Table III-25. Consumption of fertilizer by class, United States, 1950-1970.

Fiscal Year	Total Fertilizer Materials Dry Bagged	 Dry Bulk	 Liquid	 Total	Mixed Fertilizers Dry Bagged	 Dry Bulk	 Liquid	Total
				(000 tons of material)				
1950	-	-	-	18,343	-	-	-	12,309
1955	-	-	-	22,726	-	-	-	15,348
1960	19,257	3,309	2,311	24,877	14,071	1,100	479	15,650
1961	18,957	3,847	2,763	25,567	13,799	1,357	579	15,735
1962	-	-	-	26,615	-	-	-	16,205
1963	-	-	4,089	28,844	-	-	782	17,157
1964	-	-	4,742	30,681	-	-	878	18,093
1965	-	-	5,352	31,836	-	-	1,032	18,386
1966	-	-	-	34,532	-	-	-	19,659
1967 1/	15,489	12,159	7,676	35,324	12,088	7,145	1,828	21,061
1968	13,900	14,313	8,427	38,522	10,828	8,214	1,989	21,031
1969	13,144	15,199	8,937	37,280	9,935	8,799	2,249	20,983
1970	12,146	15,822	9,977	37,945	9,203	8,974	2,541	20,718

1/ Excludes Alaska, Hawaii, and Puerto Rico, and secondary and micronutrient materials.

Source: Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, Dec., 1971.

Table III-26. Bulk blend plants in the United States.

Year	New England and Middle Atlantic	South Atlantic and East South Central	East North Central	West North Central	West South Central	Mountain and Pacific [1]	Total
1959	1	4	103	83	-	10	201
1960	-	-	-	-	-	-	441
1961	-	-	-	-	-	-	736
1962	-	-	-	-	-	-	908
1963	-	-	-	-	-	-	1,326
1964	25	73	515	708	65	150	1,536
1965	-	-	-	-	-	-	2,551
1966	158	362	900	1,110	254	369	3,153
1967	-	-	-	-	-	-	3,650
1968	153	343	1,360	1,554	325	405	4,140
1969	-	-	-	-	-	-	4,649
1970	190	458	1,622	2,041	388	459	5,158

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[1] Including Hawaii.

Source: Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, Dec. 1971.

The advent of bulk blending has also somewhat altered the role of the conventional mixed fertilizers. In 1950, 70 percent of the dry fertilizers were mixed, but by 1970 mixed fertilizers had declined to 60 percent.

A third factor development in distribution has been the liquid mixed fertilizer plant which is generally a corollary to the dry bulk blend plant and thus is an integral part of the retail outlet. The number of these units has increased from 335 in 1959, to 2,751 in 1970. Growth in the tonnage of liquids was similar (Table III-27).

These trends toward more economic distribution systems have had important implications in terms of fertilizer materials demanded. These trends have resulted in shifts toward D.A.P., triple superphosphate, ammonia, etc., which these systems use, away from the mixtures and NSP.

The rapid expansion of new distribution systems has required considerable new investment; in fact this investment is probably greater than the investment in basic production facilities. The rapidity with which all of this has occurred--largely prompted by the desire of producers to control retail outlets--has resulted in overcapacity at the retail level. Thus, the producers have been faced not only with excess productive capacity but with excess retail distribution capacity.

Fertilizer Pricing

Wholesale pricing and prices - Prices of nitrogen and phosphate fertilizers have been and will continue to be largely determined by two factors - absorption of new production technology and supply/demand relationships. These two factors have exerted major influences upon industry structure and organization as well as upon prices.

The industry is highly competitive with a relatively large number of producers. No one supplier can be considered as dominant in the industry. One company may be an exception among phosphate producers but it is a cooperative enterprise. And, in consideration of its recently altered supply-purchase relationships and commitments, this singular enterprise possibly is now a net purchaser of fertilizer materials. However, even if a producer did emerge as a dominant entity in any individual product segment, the cross elasticity of demand would reduce its dominance to negligible proportions.

Table III-27. Liquid mix fertilizer plants in the United States, 1959-1970

Year	New England and Middle Atlantic	South Atlantic and East South Central	East North Central	West North Central	West South Central	Mountain and Pacific 1/	Total
1959	17	20	104	59	26	109	335
1960	-	-	-	-	-	-	390
1961	-	-	-	-	-	-	538
1962	-	-	-	-	-	-	556
1963	-	-	-	-	-	-	617
1964	23	72	190	201	56	175	717
1965	-	-	-	-	-	-	975
1966	34	103	339	375	125	255	1,231
1967	-	-	-	-	-	-	1,480
1968	42	176	394	626	173	316	1,727
1969	-	-	-	-	-	-	2,239
1970	52	285	722	1,088	209	395	2,751

1/ Including Hawaii.

Source: Fertilizer Trends, No. Y-40, Tennessee Valley Authority, Muscle Shoals, Alabama, Dec., 1971.

At the same time, on the demand side, the industry is comprised of many buyers. Until recently, there has been some concentration of purchasing power in the cooperatives; however, they have since integrated to basic production of fertilizer raw materials and subsequently have reduced their buying power . The industry, by and large, appears to have now stabilized and no one buyer dominates the field. Quite probably, the former buying power of the cooperatives may have had a long-term effect in lowering prices in the industry; but any such influence was probably slight compared to the substantial price decline brought about by adoption of new, low-cost technology and mounting over-supply of most fertilizer materials in the late sixties.

Consequently, the fertilizer industry is highly competitive. Market information is exchanged freely through trade associations and personal communication and, in the short run, prices reflect changing supply/demand relationships. In the past, high cost firms have felt these ramifications and were forced to adjust accordingly.

In the longer run, prices have reflected the acceptance of new technology. In both the basic nitrogen (ammonia) and phosphate (wet-process phosphoric acid) industry components with the advent of (1) centrifugal compressors and large scale single unit ammonia production lines and (2) large-scale phosphoric acid production units, the prices of both these products and their derivatives have decreased substantially by as much as 50 percent in some instances. Many older, smaller, high-cost producing units have since closed as a result of the competitive impact brought about by the adoption of this new lower-cost technology. Moreover, in addition to acceptance of this new technology, the industry overexpanded during the mid-to-late sixties thereby forcing a reduction in rates of operations for all firms. Operating rates dropped to 73 and 69 percent for N and P_2O_5 respectively and prices deteriorated to break-even levels for large firms which equated to less than break-even for smaller firms.

Today, even though operating rates have recovered and are up to 90 to 95 percent levels, prices have not regained their former levels prior to the introduction of this new technology -- nor are they expected to regain such levels.

The production of ammonia and wet-process phosphoric acid, the basic intermediates for most nitrogen and phosphate fertilizer derivatives, is a capital intensive industry. Prices have tended to range from below and up to the levels which would yield a 15 percent after-tax return on total investment. This appears to be a characteristic of the fertilizer industry and the observer may be able to conclude that this is the minimum return for which most companies will invest capital for expansion or for maintenance of existing operations.

Since the industry has usually tended to over-react to high prices and subsequently over-expand, actual returns appear to average out at approximately 8 percent.

While the 15 percent return factor appears to set the upper limits on price, a break-even situation appears to set the lower limit. The industry, in its present stage of progression, is moving toward the upper limit on price and is being encouraged to expand.

Even though the cost of capital goods has continually escalated, the economies inherent in large-scale unit operations in the fertilizer industry has resulted in a lowering of investment per annual ton of capacity. From small to large scale of operation, the investment per ton of annual capacity has dropped from $120 to $51 for ammonia and from $140 to $71 for phosphoric acid. According to our behavioral formula for the fertilizer industry and knowing the intrinsic costs of operations, these investments must yield about a 42-46 percent return before capital charges to cover depreciation, maintenance, local taxes, insurance, in order to provide an after-tax 15 percent return, assuming a 50 percent tax rate.

In absolute dollars, the price of ammonia (plant net-back) for a large size unit could be $29 per ton less than that of a small size unit and provide equal return on investment, while the price of phosphoric acid (plant net-back) for a large size unit could be $31 per ton less than that of a small size unit and provide equal returns. For diammonium phosphate, a comparable plant net-back price would be $20 per ton less. These figures are based on operating rates of 100 percent. At lower operating rates, the spread would widen. This relationship undoubtedly accounts for the emergence of the large sized plant and the disappearance of small sized plants -- and also accounts for the lower prevailing prices in the market place.

Recently, and especially during the years 1967 - 1970, excess capacity, price instability and erosion have been initiated at the producer or wholesale level of the industry. Most majors -- even the more vertically-integrated producers who advocate pure stability -- stand relatively helpless before price degenerating situations. This situation has been aggravated by pricing policies of new corporate entrants with limited knowledge about the industry. Many decisions have been made without a full knowledge of their far-reaching ramifications.

The price situation also has been aggravated by market-share pricing. During recent years, many producers were forced to cut back production. They were concerned about maintaining market share. They wanted to move product volumes and they sought to maintain viable outlets. Price-cutting has been the major mechanism for accomplishing this end and prices have generally eroded over the latter part of the past decade. The entrance of outside interests and the progress of vertical integration have increased competition; it has been severe, and a serious effort has not been made to maintain producer margins -- only to protect variable costs.

In short, the wholesale pricing of fertilizer materials has been on a competitive basis without price leaders or attention to the economic structure of the industry. Each producer has been willing to meet competitors' prices and the general price level has declined.

It should be noted that ammonia is priced in a fashion similar to gasoline, whereby freight equalization and intercompany trades are made, so that companies can be competitive in one another's supply territories. Manufactured nitrogen fertilizer and other fertilizers are not subject to these pricing mechanisms.

Wholesale list prices for fertilizers have become virtually meaningless over the past ten years due tothe various concessions (i.e., volume discounts, terms) which manufacturers offer buyers. As a consequence, no reliable wholesale price series exist. In order to provide some insights into wholesale prices, Table III-28 presents estimates of prices which the Contractor has developed at various times over the years. These prices in relation to the average retail prices shown in Table III-6 are much lower, indicating the significant distribution costs for storage and transportation.

Retail prices and pricing - Until recent years the retail market was served by many dealers who in turn were serviced by numerous suppliers -- D.A. materials from basic producers and mixtures from mixed goods manufacturers. As a result, each dealer and his supplier priced competitively consistent with their best interest. Even today with some control of the retail function exercised by majors, none is strong enough to exercise price leadership sufficient to stabilize pricing and the margins received. Retail margins on mixed goods of 15 to 20 percent a few years ago have shrunk to 10 to 15 percent today. The advent of bulk blending and fluid mixing have brought additional pressure to cut retail prices.

Table III-28. Estimated average realized wholesale prices for selected fertilizer products, f.o.b. plant, 1964-1973

Year	Ammonia small plant	Ammonia large plant	Ammoniun nitrate	Urea	Granular ammonium sulfate	Diammonium phosphate	Triple Super-phosphate	Normal Super-phosphate
1964	$78.00	$	$57.00	$80.00	$34.00	$75.00	$48.50	$ -
1965	78.00		56.00	78.00	34.00	73.50	49.25	-
1966	78.00		53.00	75.00	34.00	70.00	48.00	-
1967	72.00	62.00	51.00	73.00	34.00	63.75	43.75	27.10
1968	50.00	40.00	45.00	64.00	28.00	49.75	37.00	28.20
1969	37.00	27.00	39.00	54.00	26.00	54.00	38.00	28.80
1970	36.00	26.00	37.00	53.00	26.00	58.00	40.00	30.40
1971	40.00	30.00	40.00	52.00	26.00	62.00	42.00	32.80
1972	41.00	31.00	41.00	52.00	26.00	66.00	46.00	34.90
1973	48.00	38.00	44.00	57.00	27.00	75.00	55.00	38.70

Source: Estimates developed by DPRA and J. M. Malk, consultant, at various points in time.
Chemical Pricing Patterns, Third Edition, Schnell Publishing Co., Ind., New York.
Chemical Marking Reporter, various issues, Schnell Publishing Co., Inc., New York.

In some of the new products, particularly fluid mixtures, where the demand and supply situation is relatively tight, it is interesting to note that pricing usually appears to be based on given target rates of return. However, the more traditional products appear to be influenced more by market share targets and coverage of variable production and distribution costs.

Traditionally, the fertilizer industry has been more concerned about price instability at the retail level than it has about wholesale price fluctuations. The industry still has this concern, but over the past five to seven years anxiety has grown because of price instability at the wholesale levels.

B. Expected Price Effects

Evaluation of probable price effects in the fertilizer industry should be considered separately for nitrogen and phosphate products [1], since it now appears that the directional change of future price levels will differ between the two segments. Thus, in evaluating probable price effects of imposition of stricter pollution standards, the situation without imposition of standards needs to be established to serve as guidelines in assessing price impacts of pollution control.

1. Future Price Levels

Primary producers of fertilizer respond readily to plant underutilization by lowering prices. Fertilizer plants have high proportion of their costs in fixed capital investment. These plants react to undercapacity by lowering prices until it is no longer economical to do so. When this point is reached, plant shutdown occurs. Marginal plants will shutdown first in such a situation. Shutdowns or price reductions will occur until the amount of capacity offered for production equals the demand at the time.

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[1] Consideration on a product by product basis would be desirable, but the necessary supply/demand relationships are virtually nonexistent. Further, base nitrogen and phosphate are the key components to fertilizer products.

Past reactions to changes in capacity utilization are shown in Table III-29. Following the introduction of the large ammonia plants in 1966, price fell to $36/ton, wholesale, in response to a 73 percent capacity utilization. Capacity utilization for ammonia during the next seven years is expected to be the opposite of what occurred in the mid-1960's. Capacity utilization required to meet 1980 projected demands based on announced expansion is 123 percent which is not feasible. Additional capacity will be required from either additional expansion or from importation. Domestic expansion will be retarded by the shortage and uncertainties regarding natural gas. In any event, this undercapacity should result in substantial price increases unless major changes occur in this situation.

Phosphorous consumption is not expected to keep pace with plant expansion. Table III-29 predicts capacity utilization for phosphorous to reach a low of 69 percent in 1975 and to improve slowly during the latter seventies, returning to 83 percent by 1980. Phosphorous capacity greatly exceeded consumption in the late sixties in much the same way as is predicted for mid-1970's. During that period of underutilization, wholesale prices fell to $49.75 /ton for ammonium phosphate. Since that time labor and other operating costs have risen with the general inflation which has been experienced. With these higher costs diammonium phosphate prices probably will fall to the $55/ton range. Prices should improve somewhat during the late seventies as capacity utilization increases in order to bring into operation those plants which closed during the low point in utilization.

2. Probable Price Effects

The imposition of stricter water quality standards will affect the nitrogen and phosphorus fertilizer industries differently. In the case of nitrogen, ammonia production is predicted to fall short of demand requirements based on prevailing price conditions. Assuming that a highly price competitive alternate source for ammonia is not found, prices will rise until $q_s = q$. With a 20 percent deficit in supply to meet projected demand at present prices, it would take a 33 percent rise in ammonia price to obtain market equilibrium, taking a short run elasticity of -.6. With a long run elasticity of -1.8 the price adjustment required for equilibrium in the long run would be an 11 percent increase. Farmer adjustment to changing fertilizer prices is gradual with only .25 percent adjustment to the desired fertilizer level occurring in any year. Thus, in three years the adjustment is only one-half complete. In this case, the price increase after three years could be expected to be around 22 percent. Assuming a moderate increase in pollution control costs, the industry should be able to cover these costs with the expected price increases.

Table III-29. Capacity Utilization[1] and wholesale prices for ammonia phosphate, [2] 1965-1973 with projections to 1983

Year	Ammonia Utilization (pct)	Ammonia Wholesale price $/ton (small plants) ($/ton)	Ammonia Wholesale price $/ton (large plants) ($/ton)	P_2O_5 Utilization (pct)	Wholesale price diammonium phosphate ($/ton)
1965	103	78	NA	100	73.50
1966	96	77	NA	92	70.00
1967	89	72	62	80	63.75
1968	73	50	40	77	49.75
1969	73	37	27	69	54.00
1970	73	36	26	84	58.00
1971	82	40	30	96	62.00
1972	85	41	31	96	66.00
1973	89	48	38	95	75.00
Projected					
1974	92	NA	NA	84	67.00
1975	94	NA	NA	69	53.00
1976	99	NA	NA	72	50.00
1977	104	NA	NA	75	52.00
1978	111	NA	NA	77	55.00
1979	116	NA	NA	80	57.00
1980	123	NA	NA	83	61.00
1981	NA	NA	NA	87	65.00
1982	NA	NA	NA	90	70.00
1983	NA	NA	NA	94	75.00

[1] Capacity utilization from Table III-18.

[2] Prices from Table III-28.

The phosphate case appears to be much different as this industry will be in a position of over capacity during the period of implementation of the new pollution control standards. Because of the capital structure in the fertilizer industry, a high portion of total cost is fixed investment costs and firms historically have responded to underutilization by cutting prices. Given the high fixed cost structure and the nature of the industry, it seems probable that the supply curve has at least two distinct elasticity conditions--being elastic below a point defined by full operating capacity and inelastic above this point.

Unfortunately the magnitude of these elasticities is not known. With the announced capacity expansion, the supply curve will shift to the right. Further, we suspect that the elasticity will increase as one moves to the right on the new supply curve relative to the present situation, meaning the present and future supply curves will diverge to the right, since demand for phosphate is increasing, although at a lesser rate than supply. (Should demand growth be stable, the price decline would be much more pronounced.) Effect of this is expected to be a significant fall in phosphate prices by 1975 to 1976.

Imposition of pollution control standards in this framework suggests that associated costs can be passed along in the long run. Thus the resultant price level in the mid-1970's will be somewhat lower than present, although higher than would be the case without pollution control. The price level will depend largely upon the size of the pollution control costs in relation to the out-of-pocket costs of the larger plants. The more efficient plants will likely cut price to a point approximating variable costs in an effort to maximize plant utilization. The less efficient production units will have to meet these prices (excepting conditions where location or other special conditions will permit a higher price). With significantly higher out-of-pocket costs, the marginal plants will likely close. Such plant closures will result in a new supply curve located to the right of the present supply curve, but left of the future supply curve (without pollution control).

Location of an equilibrium point would require an iterative analysis since a new intermediate supply curve, with a higher price, would induce some of the less marginal plants to continue operations creating a different industry supply curve. However, the essential point is that it is likely that the price for basic phosphate products will decline during a period when pollution controls may be implemented. However, the price decline in the longer run is not expected to be as great with pollution control as without control. The extent of this decline will, however, depend upon the change in costs of the larger firms. If it is small, a number of marginal firms may be facing closure; if large, the number should be less.

IV. ECONOMIC IMPACT ANALYSIS METHODOLOGY

The following economic impact analysis utilizes the basic industry information developed in Chapters I-III plus the pollution abatement technology and costs provided by Environmental Protection Agency. The impacts examined include:

Price effects
Financial effects
Production effects
Employment effects
Community effects
Other effects

Due to the crucial nature of potential plant shutdowns (financial and production effects) to the other impacts, a disproportionate amount of time will be devoted to the financial and plant closure analysis.

In general, the approach taken in the impact analysis is the same as that normally done for any feasibility capital budgeting study of new investments. In the simplest of terms, it is the problem of deciding whether a commitment of time or money to a project is worthwhile in terms of the expected benefits derived. This decision process is complicated by the fact that benefits will accrue over a period of time and that in practice the analyst is not sufficiently clairvoyant nor physically able to reflect all of the required information, which by definition must deal with projections of the future, in the cost and benefit analysis. In the face of imperfect and incomplete information and time constraints, the industry segments were reduced to financial relationships insofar as possible and the key non-quantifiable factors were incorporated into the analytical thought process to modify the quantified data. The latter process is particularly important in view of the use of model plants in the financial analysis. In practice, actual plants will deviate from the model and these variances will be considered in interpreting financial results based on model plants.

A. Fundamental Methodology

Much of the underlying analysis regarding prices, financial and production effects is common to each kind of impact. Consequently, this case methodology is described here as a unit with the specific impact interpretations being discussed under the appropriate heading following this section.

The core analysis for this inquiry was based upon synthesizing physical and financial characteristics of the various industry segments through model or representative plants. Estimated financial profiles and cash flows for 1972 conditions were presented in Chapter II. However, as pointed out in Chapter III, significant price and cost changes are expected to occur over the next few years in the fertilizer industry. In order to reflect these expected conditions, model plant budgets were adjusted from the 1972 base data to form the underlying financial base for the economic analysis described below. The extent of these changes are described in the appropriate sections of Chapter VI--Impact Analysis. The primary factors involved in assessing the financial and production impact of pollution control are profitability changes, which are a function of the cost of pollution control and the ability to pass along these costs in higher prices. Admittedly, in reality, closure decisions are seldom made on a set of well defined common economic rules, but also include a wide range of personal values, external forces such as the ability to obtain financing or considering the production unit as an integrated part of a larger cost center where total costs must be considered.

Such circumstances include but are not limited to the following factors:

1. There is a lack of knowledge on the part of the owner-operator concerning the actual financial condition of the operation due to faulty or inadequate accounting systems or procedures. This is especially likely to occur among small, independent operators who do not have effective cost accounting systems.

2. Plant and equipment are old and fully depreciated and the owner has no intention of replacing or modernizing them. He can continue in production as long as he can cover labor and materials costs and/or until the equipment deteriorates to an irrepairable and inoperative condition.

3. Personal values and goals associated with business ownership that override or ameliorate rational economic rules is this complex of factors commonly referred to as a value of psychic income.

4. The plant is a part of a larger integrated entity and it either uses raw materials being produced profitably in another of the firm's operating units wherein an assured market is critical or, alternatively, it supplies raw materials to another of the firm's operations wherein the source of supply is critical. When the profitability of the second operation offsets the losses in the first plant, the unprofitable operation may continue indefinitely because the total enterprise is profitable.

5. The owner-operator expects that losses are temporary and that adverse conditions will dissipate in the future. His ability to absorb short-term losses depends upon his access to funds, through credit or personal resources not presently utilized in this particular operation.

6. There are very low (approaching zero) opportunity costs for the fixed assets and for the owner-operator's managerial skills and/or labor. As long as the operator can meet labor and materials costs, he will continue to operate. He may even operate with gross revenues below variable costs until he has exhausted his working capital and credit.

7. The value of the land on which the plant is located is appreciating at a rate sufficient to offset short-term losses, funds are available to meet operating needs and opportunity costs if the owner-operator's managerial skills are low.

The above factors, which may be at variance with common economic decision rules, are generally associated with proprietorships and closely held enterprises rather than publicly held corporations.

While the above factors are present in and relevant to business decisions, it is argued that common economic rules are sufficiently universal to provide a useful and reliable insight into potential business responses to new investment decisions, as represented by required investment in pollution control facilities. Thus, economic analysis will be used as the basic analytical procedure. Given the pricing conditions, the impact on profitability (and possible closure) can be determined by simply computing the ROI (or any other profitability measure) under conditions of expected prices and incremental investment in pollution control. The primary consequence of profitability changes is the impact on the plant regarding plant shutdown rather than making the required investment in meeting pollution control requirements.

In the most fundamental case, a plant will be closed when variable expenses (Vc) are greater than revenues (R) since by closing the plant, losses can be avoided. However, in practice plants continue to operate where apparently $Vc > R$. Reasons for this include:

- Lack of cost accounting detail to determine when Vc > R.

- Opportunity cost of labor or some other resource is less than market values. This would be particularly prevalent in proprietorships where the owner considers his labor as fixed.

- Other personal and external financial factors.

- Expectations that revenues will shortly increase to cover variable expenses.

A more probable situation is the case where Vc < R but revenues are less than variable costs plus cash overhead expenses (TCc) which are fixed in the short run. In this situation a plant would likely continue to operate as contributions are being made toward covering a portion of these fixed cash overhead expenses. The firm cannot operate indefinitely under this condition, but the length of this period is uncertain. Basic to this strategy of continuing operations is the firm's expectation that revenues will increase to cover cash outlay. Factors involved in closure decisions include:

- Extent of capital resources. If the owner has other business interests or debt sources that will supply capital input, the plant will continue.

- Lack of cost accounting detail or procedures to know that TCc > R, particularly in multiplant or business situation.

- Labor or other resources may be considered fixed and the opportunity cost for these items is less than market value.

Identification of plants where TCc > R, but Vc < R leads to an estimate of plants that should be closed over some period of time if revenues do not increase. However, the timing of such closures is difficult to predict.

The next level of analysis, where TCc < R, involves estimating the earnings before and after investment in pollution abatement. So long as TCc < R it seems likely that investment in pollution control will be made and plant operations continued so long as the capitalized value of earnings (CV), at the firm's (industry) cost of capital, is greater than the scrap or salvage value (S) of the sunk plant investment. If S > CV, the firm could realize S in cash, reinvest and be financially better off. This presumes reinvesting at least at the firm's (industry) cost of capital.

Computation of CV involves discounting the future earnings flow to present worth through the general discounting function:

$$V = \sum_{n=1}^{t} A_n (1+i)^{-n} \quad .$$

where

V = present value
A_n = a future value in n^{th} year
i = discount rate as target ROI rate
n = number of conversion products, i.e., 1 year, 2 years, etc.

It should be noted that a more common measure of rate of return is the book rate, which measures the after-tax profits as a ratio of invested capital to net worth or sales. These ratios should not be viewed as a different estimate of profitability as opposed to DCF measures (discounted cash flow) but rather an entirely different profitability concept. The reader is cautioned not to directly compare the DCF rates with book rates.

The two primary types of DCF measures of profitability are used. One is called the internal rate of return or yield and is the computed discount rate (yield) which produces a zero present value of the cash flow. The yield is the highest rate of interest the investor could pay if all funds were borrowed and the loan were returned from cash proceeds of the investment. The second DCF measure is the net present value concept. Rather than solve for the yield, a discount rate equivalent to the firm's cost of capital is used. Independent investments with net present values of above zero are accepted; those below zero are rejected. The concept of comparing capitalized earnings with the sunk investment value is a variation of the net present value method.

The data input requirements for book and DCF measures are derived, to a large extent, from the same basic information although the final inputs are handled differently for each.

1. Benefits

For purposes of this analysis, benefits for the book analysis have been called after-tax income and for the DCF analysis after-tax cash proceeds. The computation of each is shown below:

$$\text{After tax income} = (1 - T) \times (R - E - I - D)$$

$$\text{After tax cash proceeds} = (1 - T) \times (R - E - D) + D$$

where

T = tax rate

R = revenues

E = expenses other than depreciation and interest

I = = interest expense

D = depreciation charges

Interest in the cash proceeds computation is omitted since it is reflected in the discount rate, which is the after-tax cost of capital, and will be described below. Depreciation is included in the DCF measure only in terms of its tax effect and is then added back so that a cash flow over time is obtained.

A tax rate of 48 percent was used throughout the analysis where a positive pre-tax value existed. In the case of model plants with negative pre-tax values, zero tax rate was assumed. Accelerated depreciation methods, investment credits, carry forward and carry back provisions were not used due to their complexity and special limitations. It is recognized that in some instances the effective tax rate may be lower in a single plant situation, but with the dominance of multiplant firms, the firm's tax rate will be close to the 48 percent rate.

2. Investment

Investment is normally thought of as outlays for fixed assets and working capital. However, in evaluating closure of an on-going plant where the basic investment is sunk, the value of that investment must be made in terms of its liquidation or salvage value, that is, its opportunity cost or shadow price.[1] For purposes of this analysis, sunk investment was taken as the sum of equipment salvage value plus land at current market value plus the value of the net working capital (current assets less current liabilities) tied up by the plant (see Chapter II for values). This same amount was taken as a negative investment in the terminal year.

The following impact analysis was based on total salvage value as defined above. The rationale for this was that the cash flows did not include any interest charges but rather brought interest charges into the analysis in the weighted cost of capital. This procedure required the use of total capital (salvage value) regardless of source. An alternative procedure would be to use as capital, net cash realization (total less debt retirement) upon liquidation of the plant. (In the single plant firm debt retirement would be clearly defined. In the case of the multi-plant firm, delineation of debt by plant would likely not be clear. Presumably this could be reflected in proportioning total debt to the individual plant on some plant parameter such as capacity or sales.) Under this latter procedure of using net realization, interest and debt retirement costs would have to be included in the cash flows.

The two procedures will yield similar results if the cost of capital and interest charges are estimated on a similar basis. The former procedure, total salvage value, was used as it gives reasonable answers and simplifies both computation and explanation of the cash flows and salvage values.

Replacement investment for plant maintenance was taken as equal to annual depreciation, which corresponds to operating policies of some managements and serves as a good proxy for replacement in an on-going business.

Investment in pollution control facilities was taken as the estimates provided by EPA and shown in Chapter V. Only incremental values were used, to reflect in-place facilities. Only the value of the involved land was taken as a negative investment in the terminal year.

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[1] This should not be confused with a simple buy-sell situation which merely involves a transfer of ownership from one firm to another. In this instance, the opportunity cost (shadow price) of the investment may take on a different value.

The above discussion refers primarily to the DCF analysis. Investment used in estimating book rates was taken as invested capital - book value of assets plus net working capital. In the case of new investment, its book rate was estimated as 50 percent of the original value.

3. Cost of Capital - After Tax

Return on invested capital is a fundamental notion in U.S. business. It provides both a measure of actual performance of a firm as well expected performance. In this latter case, it is also called the cost of capital. The cost of capital is defined as the weighted average of the cost of each type of capital employed by the firm, in general terms, equities and interest bearing liabilities. There is no methodology that yields the precise cost of capital, but it can be approximated within reasonable bounds.

The cost of equities was estimated by two methods -- the dividend yield method and the earnings stock price (E/P ratio) method. Both are simplifications of the more complex DCF methodology. The dividend method is:

$$k = \frac{D}{P} + g$$

where

k = cost of capital
D = dividend yield
P = stock price
g = growth

and the E/P method is simply

$$k = E/P$$

where

E = earnings
P = stock price

and is a further simplication of the first. The latter assumes future earnings as a level, perpetual stream.

The after tax cost of debt capital was estimated from reported (annual financial reports and financial statistics) company outlays for interest expenses and multiplying by .52 -- assuming a 48 percent tax rate. These values were weighted by the respective equity to total asset and total liabilities[1] to total asset ratios.

The average cost of capital for the fertilizer industry was estimated using the equity and debt data from Chapter II as follows:

Capital	Weight	Cost	Growth	Cost
Dividend Yield Plus Growth				
Equity	.74	.039	.04	.058
Debt	.26	.039	--	.010
Average cost of capital				.068
E/P				
Equity	.74	.063	--	.047
Debt	.26	.039	--	.010
Average cost of capital				.057

As shown in the above computations, the estimated after-tax cost is 5.7 to 6.8 percent. The subsequent analysis was based on 6.0 and 7.0 percent. The upper estimate presumes a four percent growth factor which is roughly equal to inflation expectations.

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[1] It is recognized that liabilities contain non-interest bearing liabilities, but its weight is believed to be an adequate proxy for the weight of debt.

4. Construction of the Cash Flow

A seventeen period cash flow was used in the analysis of BPT (Best Practical Technology) and BAT (Best Available Technology) effluent control and was constructed as follows:

1. Sunk investment (salvage market value of fixed assets plus net working capital) taken in year t_o, assumed to be equivalent to 1976,
2. After tax cash proceeds taken for years t_1 to t_{16}
3. Annual replacement investment, equal to annual current depreciation taken for years t_1 to t_{16} (in certain cases this was assumed to be deferred. The cases are described in Chapter VI).
4. Terminal value equal to sunk investment taken in year t_{17}.
5. Incremental pollution control investment taken in year t_o for 1977 standards and year t_6 for 1983 standards.
6. Incremental pollution expenses taken for years t_1 to t_{16} for 1977 standards and years t_7 to t_{16} for 1983 standards, if additive to the 1977 standards.
7. Replacement investment taken in year t_{11} on incremental pollution investment in BPT on assumption of a 10 year life as provided by EPA. No replacement was taken for the BAT investment as it completed its life in year t_{16}.
8. No terminal value of pollution facilities was taken in year t_{17} since the land value was assumed to be very small and/or zero.

B. Price Effects

At the outset, it must be recognized that price effects and production effects are intertwined with one effect having an impact upon the other. In fact, the very basis of price analysis is the premise that prices and supplies (production) are functionally related variables which are simultaneously resolved.

Solution of this requires knowledge of demand growth, price elasticities, supply elasticities, the degree to which regional markets exist, the degree of dominance experienced by large firms in the industry, market concentration exhibited by both the industry's suppliers of inputs and purchasers of outputs, organization and coordination within the industry, relationship of domestic output with the world market, existence and nature of complementary goods, cyclical trends in the industry, current utilization of capacity and, exogenous influences upon price determination (e.g., governmental regulation).

In view of the complexity and diversity of factors involved in determination of the market price, a purely quantitative approach to the problem of price effects is not feasible. Hence, the simultaneous considerations suggested above will be made. The judgment factor will be heavily employed in determining the supply response to a price change and alternative price changes to be employed.

As a guide to the analysis of price effects, the estimated price required to leave the model plant segment as well off will be computed. The required price increase at the firm level will be evaluated in light of the relationship of the model plant to the industry and the understanding of the competitive position of the industry. The required price increase can be readily computed using the DCF analysis described above, but dealing only with the incremental pollution investment and cash proceeds.

Application of the above DCF procedure to these costs will yield the present value of pollution control costs (i.e., investment plus operating cost less tax savings). If this is known, the price increase required to pay for pollution control can readily be calculated by the formula

$$X = \frac{(PVP)\,(100)}{(1-T)\,(PVR)}$$

where:

X = required percentage increase in price

PVP = present value of pollution control costs

PVR = present value of gross revenue starting in the year pollution control is imposed

In the case of phosphates, where significant price and supply changes are expected, the above approach was not used. Rather, unit costs of effluent controls were examined over the 1977 to 1983 period and the expected price increase was based on the analysts' judgment of the amount of costs that could be passed on in any time period. During 1977 and 1978, it is anticipated that cash flows will be near zero or zero, and in this situation only the out-of-pocket costs will be passed along. As conditions improve, full costs would then be passed along. The details of this analysis are included in Chapter VI under Price Effects.

C. Financial Effects

In Chapter II, the financial characteristics of model plants were presented as reflecting 1972 conditions. As indicated above, adjustments were incorporated to reflect expected future economic conditions in the fertilizer industry. These adjusted financial data will serve as the base point for the analysis of financial effects of effluent control. Conditions without and with effluent controls will be computed, so that differences can be noted. The primary focus of analysis will be upon profitability in the industry and the ability of the firms to secure external capital. Hence, it is obvious that this portion of the analysis cannot be divorced from production effects since profit levels and the ability to finance pollution abatement facilities will have a direct influence on supply responses -- utilization of capacity and plant closures.

In addition to these factors, an additional measure of economic profitability was examined: present values estimated by the procedures described in Section A above. This measure was calculated on pre-and post-pollution control bases.

Given these financial measures, the ability of the industry to finance the required pollution control expenditures will be reexamined in light of the financial results and the information shown in Chapter II. This ability will vary from one industry subsector to another due to differential financial structures, profitability and abatement requirements. Hence, capital availability and cost will probably have to be examined on a model plant by model plant basis.

D. Production Effects

Potential production effects include reductions of capacity utilization rates, plant closures and stagnation of industry growth. It is anticipated that reductions in capacity utilization will be estimated via qualitative techniques given the analysts' knowledge of the industry. The same is true for assessing the extent to which plant closures may be offset by increases in capacity utilization on the part of plants remaining in operation. Data limitations and time constraints are expected to require that the impact of pollution control standards upon future growth of the industry also be estimated via qualitative methods.

The remaining effect, plant closures, is very difficult to estimate as discussed above in Section A. As a starting point in the plant closure analysis, the economic shutdown model will be employed to indicate which model plants might close. These conclusions will be based upon the decision rule that a plant will be closed when the net present value of the cash flow is less than zero.

It is recognized that the use of models to represent an industry is imperfect and that not all of the relevant values or factors can be included in the models. Hence, in this industry, the appropriate model plant results will be equated with each fertilizer plant and the variances to the model plant parameters will be subjectively evaluated to arrive at an estimate of the probability of closure. Three closure levels will be estimated -- high, medium and low.

The above analysis will first be performed for plants without pollution control, then, the analysis will be made with pollution control. The former will establish a baseline against which total closures after pollution control will be compared to estimate closures due to pollution control.

As discussed under fundamental methodology above, plants may continue to operate in the face of more worthwhile uses of capital tied up by the plant. In such cases the plant, particularly single or few plant firms and closely-held firms would at least have to meet cash flow requirements, where cash flow is defined as sales less operating expenses, depreciation, interest, and taxes plus depreciation less debt amortization. Although the model plant data are not of sufficient quality for a plant by plant analysis, model plants were also examined on a cash flow basis.

E. Employment Effects

Given the production effects of estimated production curtailments, potential plant closings and changes in industry growth, a major consideration arises in the implications of these factors upon employment in the industry. The employment effects stemming from each of these production impacts will be estimated. To the extent possible, the major employee classifications involved will be examined as will the potential for re-employment.

F. Community Effects

The direct impacts of job losses upon a community are immediately apparent. However, in many cases, plant closures and cutbacks have a far greater impact than just the employment loss. Multiplier effects may result in even more unemployment. Badly needed taxes for vital community services may dwindle. Community pride and spirit may be dampened. However, in some cases, the negative community aspects of production effects may be very short-term in nature with the total impact barely visible from the viewpoint of the overall community. In a few cases, the closure of a plant may actually be viewed as a positive net community effect (e.g., a small plant with a high effluent load in an area with a labor shortage).

These impact factors will be qualitively analyzed as appropriate.

G. Other Effects

Other impacts such as direct balance of payments effects will also be included in the analysis. This too will involve qualitative analyses.

V. EFFLUENT CONTROL COSTS

Water pollution control costs used in this analysis were based on cost parameters furnished by the Effluents Guidelines Division of the Environmental Protection Agency. These costs relate to the three levels of effluent controls which have been established for the various segments of the fertilizer industry. The levels are as follows:

BPT - Best practicable control technology currently available - to be achieved July 1, 1977.

BAT - Best available technology economically achievable - to be achieved by July 1, 1983.

NSPS - New source performance standards - to be applied to all new facilities that discharge directly to navigable waters - to be met by approximately January 1, 1974.

A fourth level - new source pretreatment standards - which would be applied to all facilities that use municipal systems constructed after promulgation of the proposed guidelines was not considered further in this report. Cost data were not provided for these standards. Further, fertilizer industry effluents are not generally considered compatible for treatment in normal municipal treatment systems.

A. Proposed Control Requirements

The effluent limitations guidelines, in terms of allowable contaminant levels, may be achieved through various technologies. EPA furnished various BPT and BAT recommended technologies which are described in the Development Document 1/ and are summarized in Table V-1.

1/ Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Basic Fertilizer Chemicals Segment of the Fertilizer Manufacturing Point Source Category (EPA - 440/1-74-011a), U.S. Environmental Protection Agency, Washington, D.C., March, 1974.

Table V-1. Proposed BPT and BAT water effluent treatment process by fertilizer product

Process	Ammonia	Ammonium nitrate 1/	Urea	Sulfuric acid	Phosphoric acid 2/	Diammonium phosphate	Triple super-phosphate
BPT							
Ammonia/condensate stripping	X	X					
Oil separation	X		X				
Stamicarbon urea hydrolysis			X				
Pond water treatment (triple liming) 3/					X		
Gypsum pond seepage					X		
Sulfuric acid effluent control				X			
BAT							
Ammonia/air stripping 4/	X	X	X				
Biological treatment 4/	X	X	X				
Ion exchange		X					

1/ Includes treatment of nitric acid intermediate.

2/ Phosphoric acid treatment also serves DAP and TSP end products.

3/ Pond water treatment (triple liming) refers to two-stage liming using lime in an amount equivalent to three stages.

4/ Only one of these treatments required.

B. Present Effluent Control Status of Fertilizer Industry

Comprehensive data are not available regarding the existing degree of water pollution control in the fertilizer industry. It is believed that effluent levels for present fertilizer plant operations are, for the most part, unacceptable in terms of the proposed effluent limitation guidelines. However, the fertilizer industry has taken strides toward pollution control and a few plants are reported to be close to or achieving the proposed effluent limitations.

The Fertilizer Institute recently released an industry survey of capital expenditures and operating costs for pollution control for the period 1967 through 1971. The basic producers, the group most nearly representing the products being examined in this study, have about $35 million capital outlays for this period, with annual operating costs of between $5.4 and $6.1 million. These companies reported anticipated capital expenditures of $61 million in 1972, 1973 and 1974. Most of this investment in pollution control is believed to have been in air pollution control.

As pointed out in the Development Document, some technology, such as steam stripping and hydrolysis, is used by a few plants. The extent of industry use is not reported nor known. Double liming in phosphoric acid production has been used for about 15 years. However, an enumeration of its use throughout the industry is not available.

Although the industry has taken strides toward effluent controls, it is believed that waste loads in general are untreated. For purposes of this analysis, it was assumed that the only in-place technology was double liming in the phosphate segment. In this instance, it was assumed that 50 percent of the industry currently practice double liming and 50 percent practice no gypsum pond treatment.

C. Water Pollution Abatement Costs by Technology

1. Technology Cost Data

The technological processes, summarized in Table V-1 for BPT and BAT levels, has been separated for cost analysis into two groups: (1) nitrogen and (2) phosphate fertilizers. The Environmental Protection Agency furnished cost data as of August, 1971, based upon 1,000 tons of product per day which is an approximation of a 350,000 ton per year plant.

Table V-2 and V-3 present investment costs and annual operating costs for each treatment process. Since these 1971 data were for a 350,000 ton per year plant, it was necessary for the contractor to adjust all costs to 1972 price levels and to varying model plant sizes. The price level change factor was 1.076, based on an average treatment plant construction index provided by EPA. For each plant under 350,000, a scale factor of .5 was used to estimate costs for smaller plants; for each plant over 350,000, a scale factor of .6 was used. 1/

2. Investment

a. Nitrogen products manufacturing

Table V-2 shows effluent control investment costs for nitrogen products. At the BPT level, hydrolysis/stamicarbon treatment requires the largest investment -- $249,000 for 1,000 tons per day and applies only to urea plants. The next largest investment -- $234,000 for steam stripping -- impacts ammonia and ammonium nitrate producers. Oil separation calls for $22,000. Table V-1 indicates the products affected by these processes.

At the BAT level, ammonia, ammonium nitrate and urea plants must install facilities for air stripping or biological treatment at investment costs of $104,000 and $118,000 respectively. The largest BAT investment is for ammonium nitrate plants for ion exchange -- $624,000.

b. Phosphate fertilizer manufacturing

Investment costs for phosphate manufacturers are shown in Table V-3. Pond-water treating, at $591,000 for triple liming and $376,000 for double liming, is the biggest investment outlay at the BPT level, followed by sulfuric acid effluent control at $250,000 and gypsum pond seepage control at $176,000. EPA determined that pond water treating and gypsum pond seepage investment costs do not change with plant size. It is possible that these costs may be somewhat overstated for smaller plants. There are no incremental BAT investments required in the phosphate segment, except as ammonia costs for BAT are charged to DAP plants.

1/ $\left[\frac{\text{Cost of A}}{\text{Cost of B}} : \frac{\text{Capacity A}}{\text{Capacity B}}\right]$ .5 or .6

The scale factors are based on plant engineering data derived from numerous industry studies and practices. The smaller factor for plants under 350,000 TPY reflects smaller economies of scale for that group compared to plants larger than 350,000 TPY.

Table V-2. Estimated investment and annual costs for effluent control technology in nitrogen fertilizer manufacturing

Nitrogen (annual capacity, 1,000 TPY)	50/52	85	105	130	160	210	285/295	340/350[1/]	525
	--------	--------	--------	--------	-$1,000-	--------	--------	--------	--------
Ammonia condensate/steam stripping									
Investment	91	117	129	143	161	181	209	234	299
Annual costs									
Energy and power	83	105	116	129	146	164	188	212	269
O & M	4	5	5	6	6	7	8	9	12
Subtotal	87	110	121	135	152	171	196	221	281
Depreciation - 10 percent	9	12	13	14	16	18	21	23	30
Interest (7.5%x.5)	3	4	5	5	6	7	8	9	11
Total	99	126	139	154	174	196	225	253	322
Oil Separation									
Investment	9	11	12	13	15	17	19	22	28
Annual costs									
Energy and power	2.4	3.0	3.3	3.7	4.2	4.6	5.4	6.0	7.6
O & M	.4	.4	.5	.5	.6	.7	.8	.9	1.1
Subtotal	2.8	3.4	3.8	4.2	4.8	5.3	6.2	6.9	8.7
Depreciation	.9	1.1	1.2	1.3	1.5	1.7	1.9	2.2	2.8
Interest	.3	.4	.5	.5	.6	.6	.7	.8	1.1
Total	4.0	4.9	5.5	6.0	6.9	7.6	8.8	9.9	12.6

continued.....

Table V-2. Estimated investment and annual costs for effluent control technology in nitrogen fertilizer manufacturing (continued)

Nitrogen (annual capacity, 1,000 TPY)	50/52	85	105	130	160	210	285/295	340/350[1]	525
	----------	----------	----------	----------	$1,000	----------	----------	----------	----------
Ion Exchange									
(Ammonium Nitrate)									
Investment		312	343	381	430		555	624	
Annual costs									
Energy and power		71	78	87	98		126	142	
O & M		13	14	15	17		22	25	
Extra manpower		172	172	172	172		172	172	
Subtotal		256	264	274	287		320	339	
Depreciation		31	34.3	38	43		56	62.4	
Interest		11.7	12.9	14.3	16.1		20.8	23.4	
Total		298.7	247.2	326.3	334.1		396.8	412.8	
Hydrolysis/Stamicarbon									
(Urea)									
Investment	97		137		171			249	
Annual costs									
Energy and power	63		88		111			161	
O & M	4		5.5		7			10	
Subtotal	67		93.5		118			171	
Depreciation	9.7		13.7		17.1			24.9	
Interest	3.6		5.1		6.4			9.3	
Total	80.3		112.3		141.5			205.2	

continued.....

Table V-2. Estimated investment and annual costs for effluent control technology in nitrogen fertilizer manufacturing (continued)

Nitrogen (annual capacity, 1,000 TPY)	50/52	85	105	130	160	210	285/295	340/350[1]	525
	$1,000								
Ammonia condensate/air stripping									
Investment	41		57		72	80	94	104	132
Annual costs									
Energy and power	2		3		4	4	5	6	7
O & M	2		2		3	3	4	4	5
Subtotal	4		5		7	7	9	10	12
Depreciation	4		6		7	8	9	10	13
Interest	1.5		2.1		2.7	3.0	3.5	3.9	5.0
Total	9.5		13.1		16.7	18.0	21.5	23.9	30.0
Biological treatment									
Investment	46		65		82	91	106	118	151
Annual costs									
Energy and power	5		7		9	10	12	13	17
O & M	2		3		3	4	5	5	6
Extra manpower	20		20		20	20	20	20	20
Subtotal	27		30		32	34	37	38	43
Depreciation	4.6		6.5		8.2	9.1	10.6	11.8	15.1
Interest	1.7		2.4		3.1	3.4	4.0	4.4	5.7
Total	33.3		38.9		43.3	46.5	51.6	53.2	63.8

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[1] Data points provided by Environmental Protection Agency in Development Document for Effluent Guidelines and Standards - Fertilizer and Phosphate Manufacturing Industry, June 1973, supplemented by direct communications to DPRA.

[2] Cost data not calculated for those capacities for which there are no model plants.

Table V-3. Estimated investment and annual costs for effluent control technology in phosphate fertilizer manufacturing

Annual Capacity, 1,000 TPY	83	200	340[1]
	($1,000)	($1,000)	($1,000)
Phosphoric Acid			
Pond water treating (0 to 3x liming)			
Investment	591	591	591
Annual costs			
Raw materials	260	260	260
Energy and power	9	9	9
O&M	24	24	24
Subtotal	293	293	293
Depreciation	59	59	59
Interest	22	22	22
Subtotal	81	81	81
Total	374	374	374
Pond water treating (2x to 3x liming)			
Investment	215	215	215
Annual costs			
Raw materials	99	99	99
Energy and power	3	3	3
O&M	8	8	8
Subtotal	110	110	110
Depreciation	22	22	22
Interest	8	8	8
Subtotal	30	30	30
Total	140	140	140
Gypsum pond seepage			
Investment	176	176	176
Annual costs			
Energy and power	5	5	5
O&M	7	7	7
Subtotal	12	12	12
Depreciation	18	18	18
Interest	7	7	7
Subtotal	25	25	25
Total	37	37	37

continued . . .

Table V-3. Estimated investment and annual costs for effluent control technology in phosphate fertilizer manufacturing (continued)

Annual Capacity, 1,000 TPY	83	200		340 [1/]
	------------	------------	($1,000)	------------
Sulfuric Acid (annual capacity, 1,000 TPY)	250	340 [1/]	600	1,000
Effluent control				
Investment	211	250	345	470
Annual costs				
Energy and power	4	5	7	10
O&M	8	10	14	19
Subtotal	12	15	21	29
Depreciation	21	25	34	47
Interest	8	9	13	18
Subtotal	29	34	47	65
Total	41	49	68	94

1/ Data points provided by EPA. Sulfuric acid annual capacities of 250,000 600,000 and 1,000,000 tons are integrated components of phosphoric acid capacities of 83,000, 200,000 and 340,000 tons respectively.

Normal superphosphate plants have been omitted from Tables V-1 and V-3 because they are not expected to have incremental pollution control costs at the BPT or BAT levels. Based on information from EPA, the sixty operating plants are believed to be operating currently at a no-discharge level, using a closed-loop recirculating wet scrubber system. If a plant does not have a wet scrubber in place (and there is no knowledge that this condition exists), it would have an air pollution problem which would require pollution controls not attributable to effluent limitations guidelines. Accordingly, no further analysis of normal superphosphate will be included. The draft development document referenced earlier also included some alternative treatment technologies (chromate removal, DAP self-contained and pond water sulfuric acid dilution). These have been analyzed in terms of costs and financial impact and are included in Appendix B but will not be further analyzed in the main body of the report.

3. Annual Operating Costs

Nitrogen products manufacturing

Annual operating costs are also presented in Table V-2. These are broken down into energy and power, operation and maintenance, extra manpower (where required), depreciation and interest. Energy and power generally are a function of investment with the percentage ratio varying by process. Operation and maintenance is 4 percent of investment. Depreciation assumes a 10-year life and is 10 percent of investment; no salvage value is further assumed. Interest is 7.5 percent of the average investment over the expected 10-year life or 3.75 percent of the original cost.

For BPT, steam stripping ($253,000) and hydrolysis/stamicarbon ($205,000) impose significant annual costs. The other processes have substantially lower annual costs. At the BAT level, ion exchange for ammonium nitrate requires a high annual cost of $413,000. It should be noted that the extra manpower requirements of the ion exchange process represent a major portion of the annual costs.

Phosphate fertilizer manufacturing

Annual costs (shown in Table V-3) of treatment technology in the phosphate segment are very high in pond water treating ($374,000). Other processes impose relatively small annual incremental operating costs ranging from $37,000 to $94,000.

It should be noted that pond water treatment costs are provided for phosphate plants with no treatment in place (0 to 3x liming) and for plants with double liming in place (2x to 3x liming). For the latter category, the incremental costs are for liming in two stages, using an amount of liming which would be required for triple liming.

D. Water Pollution Abatement Costs by Model Plant

The costs of treatment technology by process must be applied to intermediate and end products in order to analyze the ultimate impact of these costs. This section explains the methodology by which the various investment and annual costs are combined for each product and plant size.

1. Technology Combinations by Product

The cost analysis of the various treatment processes requires not only the combining of costs of all processes for each product (as summarized in Table V-1); it also must account for the flow-through of investment and operating costs of intermediate product treatment processes.

Table V-4 lists the prorate factors used in determining the allocation of intermediate product treatment costs to the end product effluent control costs. These were the same prorate factors used in the model plant investment and operating cost studies in Chapter II. The costs for BPT ammonia effluent control have been calculated by adding the investment cost for steam stripping and oil separation. There is no prorating necessary for ammonia.

Ammonium nitrate reflects not only the costs of steam stripping but also a prorata share of the investment and annual costs of the ammonia used in the production of ammonium nitrate. Other products have been analyzed in the same manner.

2. Best Practical Technology Cost

The product combinations discussed above have been further broken down by model plant size. Table V-5 reports the initial investment required and the estimated annual operating costs for each model plant.

Table V-4. Plant sizes, configurations and prorate factors used in estimating effluent control costs for model plants

Product	Capacity (1000 TPY)	Ammonia Capacity (1000 TPY)	Ammonia Prorate factor (Pct)	Sulfuric Acid Capacity (1000 TPY)	Sulfuric Acid Prorate factor (Pct)	Phosphoric Acid Capacity (1000 TPY)	Phosphoric Acid Prorate factor (Pct)
Ammonia	50						
	105						
	210						
	350						
	525						
Ammonium nitrate	105	210	11				
	160	210	17				
	350	350	22				
Urea	52	105	30				
	105	210	30				
	160	350	28				
	350	525	41				
Diammonium phosphate	170	50	78	250	100	83	100
	330	105	72	600	78	200	100
	720	210	79	1,000	100	340	100
Triple superphosphate	170			250	71	83	100
	330			600	58	200	100

Note: Above used in adding share of effluent control costs for intermediate processes to end product effluent costs.

Table V-5. Estimated incremental investment and annual costs for BPT and BAT effluent controls for model plants

		BPT				BAT			
Product	Capacity (1000TPY)	Invest-ment	Expenses	Depreci-ciation	Interest	Invest-ment	Expenses	Depreci-ciation	Interest
Ammonia	50	100	90	10	4	41	4	4	2
	105	141	125	14	5	57	5	6	2
	210	198	176	20	8	80	7	8	3
	350	256	228	26	10	104	10	10	4
	525	327	290	33	12	132	12	13	5
Ammonium nitrate	105	151	140	15	5	406	218	41	15
	160	195	182	20	7	512	295	51	19
	350	290	271	29	10	741	350	74	28
Urea	52	148	108	15	6	58	6	6	2
	105	208	151	21	8	81	7	8	3
	160	258	187	26	10	121	10	12	5
	350	405	297	41	15	158	15	16	6
Diammonium phosphate (0 - 3x)	170	1,056	387	106	40	32	3	3	1
	330	1,138	415	114	43	41	4	4	2
	720	1,393	484	139	53	63	6	6	2
Diammonium phosphate (2x - 3x)	170	680	204	68	26	32	3	3	1
	330	762	232	76	29	41	4	4	2
	720	1,017	301	102	39	63	6	6	2
TSP (0 - 3x)	170	917	314	92	37	(No incremental BAT costs)			
	330	967	317	97	39				
TSP (2x - 3x)	170	541	131	54	22				
	330	591	134	59	24				

In computing the various costs for Table V, DPRA assumed a separate treatment facility for each required process. It must be recognized that a common treatment facility might be feasible in a multiplant complex. For example, a complex for ammonia, urea and ammonia nitrate production could conceivably install a steam stripping facility large enough to accommodate the combined output of all three product plants. Through economy of scale, both investment and annual operating costs per ton of product would be appreciably lower.

Including costs of separate rather than common treatment facilities results in the maximum of estimated incremental costs. If impact analysis shows that a model plant can financially absorb these maximum costs, it follows that a lesser impact will result from savings through common treatment.

It was noted earlier that some producers may already have some of the required control technology in place. No allowance has been made for this contingency, except in the phosphate segment. Recognizing that some phosphoric acid plants may already be double-liming ponds, Table V-5 includes costs for such plants. Those will have appreciably lower investment and operating costs than plants which must triple-lime their ponds.

3. Best Available Technology

Table V-5 also includes the BAT investment and annual operating costs for each model plant. These have been computed in the same manner as those for the BPT level. BAT costs are additive to BPT costs.

4. New Source Performance Standards

Standards for new plants coming on line after January 1, 1974, have also been established by Effluent Guidelines. In the phosphate subcategory, the standards are the same as BAT level controls. Thus, the technologies and costs used for phosphate plants are BPT plus BAT.

For the nitrogen subcategory, some effluent limitations are less stringent for new sources than for 1983 (BAT) levels for existing plants. EPA did not furnish new source technologies and costs, on the grounds that some of the 1983 technologies are not commercially available and have not yet been refined. For consistency in the economic analysis, however, it was necessary to assume that BPT plus BAT technologies and costs would provide an upper limit of new source pollution control costs.

It is recognized that in new construction, effluent controls will be built into the process rather than end-of-the-pipe changes presumed for existing plants. It seems probable that this method of constructing effluent control facilities would reduce both investment and operating costs. NSPS costs used in the impact analysis may be overstated. The extent of this is not known.

VI. IMPACT ANALYSIS

The impacts considered in this analysis include the following:

A. Price effects
B. Financial effects
C. Production effects
D. Employment effects
E. Community effects
F. Balance of payment effects

A comprehensive and detailed impact analysis of each of the above was beyond the scope of this study. Consequently, efforts were allocated more to financial and plant closure analyses, with lesser detail allocated to macro-impacts.

In analyzing price, financial and production impacts, certain assumptions about industry conditions after 1977 had to be made. These assumptions are quite different for the nitrogen and phosphate segments.

There is much uncertainty about the future of the nitrogen fertilizer industry, engendered primarily by the natural gas situation. At the present writing, there are strong indications that natural gas will be in short supply for the next decade and that industrial users will undoubtedly be on interruptable supply. This analysis assumes that little expansion will take place in the ammonia industry, although demand will increase. Accordingly, prices are expected to improve substantially over 1972 levels.

Estimated wholesale prices per ton, listed below, assume a 90 percent utilization level for model plants:

Year	Ammonia ($/Ton)	Ammonium nitrate ($/Ton)	Urea ($/Ton)
1973	$38 ($48) [1]	$44	$57
1974	$40 ($50) [1]	$46.50	$60
1975 and after	$43 ($53) [1]	$49	$63

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[1] The figure in parenthesis allows a higher local price for 50,000 and 105,000 TPY plants.

The 90 percent utilization factor is based on the assumption that ammonia plants will probably operate at full capacity while natural gas is available but will cease production periodically during gas shortages. There is no way to forecast accurately actual levels of utilization. New sources of natural gas feedstock, other feedstocks or new technologies not currently in use could radically alter the outlook.

In addition to the foregoing price assumptions, certain cost assumptions had to be made. There are no current reliable guides to future cost data. Obviously inflation will occur at some indeterminate rate but should affect prices and costs at roughly the same rate. At the same time, there will probably be real cost increases due to shifts in supply-demand relationships. This analysis has assumed a real cost increase rate of four percent annually for labor and materials costs; 1977 costs have been adjusted to reflect this annual rate. After 1977, prices of nitrogen fertilizer products and costs have been held constant on the assumption that they will change at the same rate after that date.

The phosphate segment offers a sharply different picture. Prices and profit margins are attractive in 1973 and have prompted some producers to announce plans to build new plants. Phosphoric acid capacity is expected to rise sharply in 1974 and 1975 if current plans for new construction are carried out. This expectation is based upon a survey of industry carried out in 1972 and updated in 1973 by Malk Associates, who also serve as consultants for this study. Further detail on capacity changes in the phosphate segments is contained in Chapter III. The pattern of prices and utilization of the 1967 to 1972 period, also described in Chapter III, can reasonably be expected to reappear.

Prices will undoubtedly fall after peaking in 1973. The analyses which follow contain these wholesale price per ton and utilization assumptions:

Year	DAP	TSP	Utilization (pct)
1973	$75	$55	95
1974	67	47	84
1975	53	37	69
1976	50	35	72
1977	52	37	75
1978	55	39	77
1979	57	40	80
1980	61	43	83
1981	65	46	87
1982	70	49	90
1983 and after	75	53	94

These prices are stated in 1972 dollars; consequently, the costs used to calculate model plant expenses and income are also in 1972 dollars.

Under the conditions described above, certain pragmatic actions by producers can be assumed. Since prices are projected to fall to a point near or equal to cash outlays, producers can be expected to reduce their costs as much as possible. Certain costs ordinarily considered fixed in the short-run can be adjusted downward in the face of falling production.

Cost adjustments will probably occur as follows:

(1) Maintenance will be deferred as much as possible.
(2) Replacement of plant and equipment -- assumed equal to annual depreciation in the model plant simulation -- will be deferred in whole or in part.
(3) Plant and labor overhead, sales, general and administrative expenses will be curtailed by laying-off personnel both to reflect the proportional decline in production and to meet the critical need to reduce expenses.

Examining the components of fixed costs used in the model plant cost data, it is reasonable to assume the following changes:

(1) Maintenance and supplies -- from 6 percent of investment to 2 percent.
(2) Taxes and insurance -- no change.
(3) Plant labor and overhead -- reduce by one-third
(4) S.G. & A. -- reduce from 15 percent of sales at 100 percent utilization to 12 percent of actual sales; also reduce the prorate from intermediate plants proportionately.
(5) Depreciation -- no change in amount.
(6) Interest -- no change in amount.

In addition to these cost reductions, we have assumed that plant and equipment replacement expenditures will be deferred until cash flows become positive; in the 170,000 TPY model plant analysis, depreciation has been added to after-tax cash proceeds for four years.

A. Price Effects

As pointed out above, significant changes of price over 1972 levels are expected. In the case of nitrogen products, a constant price level was assumed to hold from 1977 onward. (It is recognized that higher prices may occur, but short gas supplies are expected to hold down utilization rates, thus offsetting the higher prices with higher operating costs.) Price levels in the phosphate segment are expected to be quite different, with price declines through 1977, followed by increase through 1983, after which prices were assumed to be constant. Thus, imposition of stricter water quality standards will affect the nitrogen and phosphate segments differently.

In the case of nitrogen, ammonia production is projected to fall short of demand requirements based on prevailing price conditions. Assuming that a highly price competitive alternate source for ammonia is not found, prices will rise until $q_s = q$. With 20 percent deficit in supply to meet projected demand at present prices, it would take a 33 percent rise in ammonia price to obtain market equilibrium, taking a short run elasticity of -.6. With a long run elasticity of -1.8, the price adjustment required for equilibrium in the long run would be an 11 percent increase. Farmer adjustment to changing ferilizer prices is gradual with only 25 percent adjustment to desired fertilizer level occurring in any year. Thus in three years the adjustment is only one-half complete. In this case, the price increase after three years could be expected to be around 22 percent. Assuming a moderate increase in pollution control costs, the nitrogen industry in general should be able to cover these costs with the expected price increases.

It is expected that costs of pollution controls will be passed on in the form of higher prices for anhydrous ammonia and urea. Because of competitive relationships among products, the full price increase required by the ammonium nitrate segment is not expected to be passed along.

The underlying rationale is that ammonium nitrate has little, if any, fundamental technical advantage relative to ammonia and urea, thus ammonium nitrate prices are not expected to increase relative to ammonia and urea price increases. All size segments within a product segment are not expected to be able to recover all of the pollution control costs due to the lower costs and competitive position of the larger units.

Table VI-1 presents the required price increase needed to maintain profitability for each product and size segment of the nitrogen industry. These rates run from 2.0 to 5.0 percent for ammonia at the BPT level plus 0.1 to 0.4 percent for the addition of BAT. Urea runs slightly higher, while the ammonium nitrate rate is significantly higher under BAT, reflecting higher costs of pollution control. Considering that larger plants have the bulk of capacity, it is projected that the price increase due to pollution control will tend to be set by these units. Based on this postulation, the following price increases due to pollution control are projected:

Product	Base Price	Expected price increase			
		Percent		$ per ton	
		BPT	BPT & BAT	BPT	BPT & BAT
	($/ton)				
Ammonia [1]	43	3.0	3.5	1.30	1.51
Ammonium nitrate	49	3.5	4.0	1.70	1.96
Urea	63	3.5	4.0	2.20	2.52

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[1] For small plants with an estimated high sales price the absolute increase would amount to $1.60 and $1.86 per ton respectively.

The ammonium nitrate price increase was held to that of urea on the assumption that ammonium nitrate is generally competitive with urea and its prices could not become far out of line with urea, yet maintain sales. The cross elasticity between these two products is not known, but as shown in Table VI-2, urea and ammonium nitrate prices have maintained a close relationship on a unit of plant food basis. In this connection, it should be noted that these expected price increases will further favor ammonia on a plant nutrient content basis. But as shown in Table VI-2, ammonia has had an historical price advantage, and these adjustments are not expected to materially change these competitive relationships.

In subsequent economic analysis, the BPT price increase was used through 1982, with the BPT and BAT price increase used thereafter.

The above price increase estimates do not differentiate between solutions and prills for urea and ammonium nitrate. The manufacturing costs used in the analysis reflect prilled production. The effluent control costs provided by EPA do not identify the type of product with which they are associated. However, it seems doubtful that the solution component will differ significantly in that several plants produce both prilled and solution forms of ammonium nitrate and urea.

Table VI-1. Required percentage price increases to maintain industry profitability with effluent controls

Model Configuration					
Product	Capacity	BPT	BAT	Total	Portion of segment
	(1000 TPY)	Pct.	Pct.	Pct.	Pct.
Ammonia	50	4.8 1/	0.4 1/	5.2 1/	6.4
	105	3.4	0.3	3.7	19.2
	210	3.0	0.2	3.2	20.9
	350	2.4	0.2	2.6	30.6
	525	1.9	0.1	2.0	22.9
Ammonium nitrate	105	3.9	5.9	9.8	44.0
	160	3.5	5.2	8.7	23.5
	350	2.4	2.6	5.0	32.5
Urea	52	2.7 1/	0.5 1/	3.2 1/	33.1
	105	3.6	0.3	3.9	19.2
	160	3.0	0.3	3.6	30.1
	350	2.2	0.2	2.4	17.6

1/ No income taxes assumed because of negative profits thus required increase is not proportionate to models with taxable income.

Table VI-2. Comparison of average realized price per pound of nitrogen in anhydrous ammonia, ammonium nitrate and urea, 1964-1973

	Anhydrous Ammonia		Ammonium Nitrate		Urea	
	Product ($/ton)	Nutrient (Cents/lb.)	Product ($/ton)	Nutrient (Cents/lb.)	Product ($/ton)	Nutrient Cents/lb.)
1964	78	4.75	57	8.51	80	8.70
1965	78	4.75	56	8.36	78	8.48
1966	78	4.75	53	7.91	75	8.15
1967	62	3.78	51	7.61	73	7.93
1968	40	2.44	45	6.72	64	6.96
1969	27	1.65	39	5.82	54	5.87
1970	26	1.59	37	5.52	53	5.76
1971	30	1.83	40	5.97	52	5.65
1972	31	1.89	41	6.12	52	5.65
1973	38	2.32	44	6.57	57	6.20
1977 E	43	2.62	49	7.31	63	6.85

Source: Calculated from wholesale prices in Table III-29.

Price effects in the phosphate case appear to be much different as this industry is expected to be in a position of over capacity during the period of implementation of the new pollution control standards (see Chapter II for supply discussion). Because of the capital structure in the fertilizer industry, a high portion of total cost is fixed investment costs and firms historically have responded to under-utilization by cutting prices. (This is an immature oligopolistic industry characterized by unorganized and non-collusive action and resultant "price wars." This is contrasted to a mature oligopolistic industry characterized by rigidity and nonprice competition.) Given the high fixed cost structure and the historical performance of the industry, it seems probable that the supply curve has at least two distinct elasticity conditions -- being elastic below a point defined by full operating capacity and inelastic above this point.

Unfortunately the magnitude of these elasticities is not known. With the announced capacity expansion, the supply curve will shift to the right. Further, we suspect that the elasticity will increase as one moves to the right on the new supply curve relative to the present situation, meaning that the present and future supply curves will diverge to the right. The demand for phosphate is increasing, although at a lesser rate than supply. The effect of this is expected to be a significant fall in phosphate prices by 1977. (Should demand growth be stable, the price decline would be much more pronounced.)

Imposition of pollution control standards in this framework suggests that associated costs can be passed along in the long run. Thus the resultant price level in the mid-1970's will be somewhat lower than present, but likely higher than would be the case without pollution control. The exact nature of the price level will depend upon the size of the pollution control costs in relation to the out-of-pocket costs of the larger plants. The more efficient plants will likely cut price to a point approximately equal to out-of-pocket costs in an effort to maximize plant utilization. The less efficient production units will have to meet these prices (excepting conditions where location or other special conditions will permit a higher price). With significantly higher out-of-pocket costs, the marginal plants will likely close. Such plant closures will result in a new supply curve located to the right of the present supply curve, but to the left of the future supply curve (without pollution control).

Location of an equilibrium point would require an iterative analysis since a new intermediate supply curve, with a higher price would induce some of the less marginal plants to continue operations, creating a different industry supply curve. However, the essential point is that it is likely that the price for basic phosphate products will decline during a period when pollution controls may be implemented. However, the price decline in the longer run is not expected to be as great with pollution control as without control. The extent of this decline will, however, depend upon the change in costs of the larger firms. If it is small, a number of marginal firms may be facing closure; if large, the number should be less.

Given this scenario, price increases equivalent to those needed to maintain profitability are not expected. Rather it is anticipated that price increases will initially approximate out-of-pocket pollution control costs and then full pollution control costs. The level of price increase is compounded by the nature of pollution control costs, as shown in Chapter V, which are largely independent of size and throughput. Thus, the units with lower throughputs are at a significant disadvantage when viewed on a per ton basis. Further, as throughput increases, the unit cost of pollution control falls in this situation.

As a basis for estimating price increases, the 330,000 ton diammonium phosphate and triple superphosphate plant data were used, since these units are believed to be the most likely trendsetters. It was further assumed that one-half of the units had double liming in place and one-half did not. The per ton costs of each situation were weighted accordingly to arrive at an average per ton cost. With the phosphate industry in a period of expected overcapacity at the time of imposition of BPT (1977), it is anticipated that only out-of-pocket costs will be passed along initially, that is 1977 and 1978. Following this, as prices strengthen, it is anticipated that full costs will be passed along. Since unit costs for BPT will decline as utilization rates improve, but will experience an increase with the addition of BAT in 1983, a single second stage price increase is projected beginning in 1979. This line of reasoning lead to the following expected phosphate price increases due to effluent controls:

Product	Year	Expected price increase ($/ton)
Diammonium phosphate	1977 and 1978	1.45
	1979 and after	1.50
Triple superphosphate	1977 and 1978	1.05
	1979 and after	1.10

It is recognized that new triple superphosphate capacity is not anticipated. However, it is thought that the decline in DAP prices will also drive down TSP prices due to the competitive relationship of these two products.

Table VI-3 displays the computed unit costs for effluent control.

Table VI-3. Estimated effluent control costs per ton for selected phosphate segments

Product	Year	No lime in place			Double lime in place			Average		
		O & M 1/	Deprec.	Total	O & M 1/	Deprec.	Total	O & M 1/	Deprec.	Total
		$ per ton								
Diammonium phosphate 330,000 TPY	1977	1.85	.46	2.31	1.05	.31	1.36	1.45	.38	1.83
	1978	1.80	.45	2.25	1.03	.30	1.33	1.42	.38	1.80
	1979	1.73	.43	2.16	.99	.29	1.28	1.36	.36	1.72
	1980	1.67	.42	2.09	.95	.28	1.23	1.31	.35	1.66
	1981	1.60	.40	2.00	.91	.27	1.18	1.26	.34	1.60
	1982	1.54	.38	1.92	.88	.26	1.14	1.21	.32	1.53
	1983	1.50	.38	1.88	.86	.26	1.12	1.18	.32	1.50
Triple superphosphate 330,000 TPY	1977	1.44	.39	1.83	.64	.24	.88	1.04	.31	1.35
	1978	1.40	.38	1.78	.62	.23	.85	1.02	.30	1.32
	1979	1.35	.37	1.72	.60	.22	.82	.98	.29	1.27
	1980	1.30	.35	1.65	.58	.22	.80	.94	.29	1.23
	1981	1.24	.34	1.58	.55	.21	.76	.90	.27	1.17
	1982	1.20	.33	1.53	.53	.20	.73	.87	.26	1.13
	1983	1.15	.31	1.46	.51	.19	.70	.83	.25	1.08

1/ Includes annual interest on pollution control investment.

It should also be noted that although diammonium phosphate is the major component of the ammonium phosphate segment, minor quantities of other grades, nitrophos, 21-53-0 and N-P-K, exist in this segment. These products were not specifically analyzed, either in terms of effluent control costs or manufacturing costs. However, it is believed that effluent control costs and pricing response will not substantially differ from DAP.

Price changes from BPT and BAT controls were used in the NSPS impact analysis. Generally, no additional price impact is expected from the implementation of NSPS in the nitrogen segment.

In the phosphate segment, NSPS could result in decisions to delay construction of new diammonium phosphate plants, in which case DAP prices might not fall as much as shown in the introductory comments of this chapter. However, it seems probable that construction will proceed as scheduled and the projected prices will be applicable.

B. Financial Effects

A financial profile of the fertilizer industry has been presented in Chapter II. Financial data, both for model plants and for the industry, reveal basic instability and widely fluctuating earnings. In 1973, the industry showed considerable strength after passing through critical years of overcapacity and low prices in the late 1960's. For the nitrogen products producers, the near future is clouded by natural gas shortages but looks basically encouraging. Phosphate producers, in response to high earnings, have announced expansion plans which threaten to depress the industry again by 1974-75. Thus, the two major segments of the industry seem to be headed into somewhat different futures.

1. Profitability

a. Nitrogen segment

The 1972 data for model plants show satisfactory levels of earnings for large plants, with ample cash flows. Net income as a percent of sales ranges from 6.0 to 12.3 percent and cash flows from $1.5 to $2.6 million.

Small ammonia and urea plants show sizeable losses in 1972 with the 50,000 TPY plants having negative cash flows. The small ammonium nitrate plant (105,000 TPY) is at about the breakeven point, although it has a positive cash flow of $347,000.

Intermediate-sized plants are producing 4 to 6 percent net income to sales, with modest cash flows.

Translating these model plant returns into meaningful terms for operating companies is extremely difficult. A company's financial strength depends upon many factors, including its degree of diversification and its size. If a company is operating only small plants, it is obviously in financial difficulty. If, on the other hand, it has a mix of large and small plants, it can carry the small plants. As noted previously, plants which are in an integrated complex may have economic values not reflected in the model plant analysis. Further, diversified companies may operate small plants at a deficit for a short period.

It is reasonable to expect ammonia and urea producers to pass on pollution control costs in the form of higher prices, with only the smaller sized plant suffering a negative impact on cash flow and profitability. Ammonium nitrate producers probably cannot increase prices enough to avoid a serious negative impact.

Table VI-4. presents estimated cash proceeds and net present values for model plants, both before and after pollution control costs have been added.

The smallest ammonia (50,000 TPY) and ammonium nitrate (105,000 TPY) plants suffer a loss in net present values, from an already negative baseline condition. The smallest urea plant (52,000 TPY) has a negative net present value which remains at about the same level after the adding of BPT and BAT costs.

All other sizes of ammonia plants have increasing net present values under pollution controls, as do all other urea plants. For the middle sized and large ammonia nitrate plants, net present values rise slightly with the imposition of BPT controls but then decline substantially after adding BAT controls.

Thus, in the nitrogen subcategory, small plant owners will see profitability reduced as a result of pollution controls, while large plant operators may actually gain over the long run, except in the ammonium nitrate segment.

b. Phosphate segment

The phosphate segment is represented in the model plant analysis by diammonium phosphate and triple superphosphate. DAP serves as a surrogate for ammonium phosphates in general and should fairly reflect conditions in this subsegment.

Table VI-4. Estimated cash proceeds and net present values for model plants without and with effluent controls - with expected price adjustments

Model Plant	Capacity 1,000 TPY	Base			BPT			BPT + BAT		
		Cash Proceeds	Net Present Value		Cash Proceeds	Net Present Value		Cash Proceeds	Net Present Value	
			6.0	7.0		6.0	7.0		6.0	7.0
Ammonia	50	-267	-3,233	-3,099	-285	-4,045	-3,849	-206	-3,664	-3,506
	105	138	539	381	158	525	361	249	957	749
	210	1,080	9,647	8,833	1,125	9,799	8,965	1,273	10,511	9,604
	350	1,956	17,748	16,296	2,061	18,418	16,909	2,307	19,621	17,991
	525	3,393	31,585	29,130	3.575	32,925	30,366	3,945	34,769	32,024
Ammonium nitrate	105	76	9	-101	95	-30	-144	-27	-947	-987
	160	477	3,737	3,336	521	3,884	3,462	416	2,981	2,628
	350	2,070	18,844	17,313	2,224	19,957	18,339	2,117	18,882	17,342
Urea	52	-831	-8,998	-8,498	-836	-9,275	-8,764	-724	-8,733	-8,279
	105	225	1,333	1,109	265	1,419	1,179	389	2,006	1,706
	160	749	6,238	5,638	829	6,652	6,012	1,019	7,554	6,820
	350	2,714	24,867	22,871	2,940	26,531	24,408	3,353	28,564	26,235
Diammonium phosphate (no liming in place)	170	1/	2,341	1,351	1/	-231	-710	1/	-254	-730
	330	1/	14,767	12,986	1/	13,639	11,848	1/	13,610	11,821
Diammonium phosphate (liming in place)	170	1/	2,341	1,351	1/	1,828	1,256	1/	1,805	1,235
	330	1/	14,767	12,986	1/	15,038	13,169	1/	15,009	13,142
Triple superphosphate (No liming in place)	170	1/	3,471	3,014	1/	1,392	1,002	1/	1,392	1,002
	330	1/	10,371	9,144	1/	9,292	8,062	1/	9,292	8,062
Triple superphosphate (No liming in place	170	1/	3,471	3,014	1/	3,027	2,562	1/	3,027	2,562
	330	1/	10,371	9,144	1/	10,723	9,420	1/	10,723	9,420

1/ Varies by year. See Table VI-5.

In 1972, the 170,000 TPY DAP and TSP model plants show negative income to sales percentages, with modest positive cash flows. The 330,000 TPY plants have net income to sales of 5 to 6 percent and $1.5 to $2.2 million cash flows. The 720,000 TPY DAP plant shows a healthy 10 percent net income to sales ratio and a $6.7 million cash flow. With prices up sharply in 1973, these positions will be much improved; the smaller plants will yield a substantial profit at the 1973 price of $75 and $55 per ton.

This strong financial position will probably have eroded by 1975. Even without pollution control costs added, negative earnings will result in the model plants for several years until prices improve substantially.

Theoretically, pollution abatement costs should further depress profitability. The cash proceeds and net present values in Tables VI-4 and VI-5 show this to be generally true. These values reflect the cost savings assumed in the introduction to this chapter and would be greatly lower without those reductions.

The 170,000 TPY DAP plant with a positive net present value without pollution control drops to a negative value with BPT and declines further with BAT, assuming no pond liming in place. The net present value of a 330,000 TPY plant remains approximately level under these assumptions.

A 170,000 TPY DAP plant with double pond liming in place would incur lower BPT costs and would experience a much smaller decrease in net present value. The 330,000 TPY DAP plant has large net present values under either set of assumptions.

TSP plants of both sizes have positive net present values under both pond liming assumptions. Only the 170,000 TPY plant with no liming in place suffers a significant drop in net present value.

It must be repeated that negative earnings occur for these model plants, while prices and utilization remain at low levels. The apparent profitability for all but the 170,000 TPY DAP plant results from greatly improved prices and utilization around 1981.

In conclusion, DAP producers may suffer further losses of profitability as a result of pollution controls. Plants smaller than 170,000 TPY will be impacted even more severely; it is doubtful that operators of such plants can cut costs sufficiently to survive the predicted low prices.

Table VI-5. Estimated cash flows for selected phosphate plants--with expected price adjustment

				No lime in place		Lime in place	
Plant	Capacity	Year	Base	BPT	BPT & BAT	BPT	BPT & BAT
	(1,000 TPY)		$1,000				
Diammonium phosphate	170	1977	-575	-770	-	-587	-
		1978	-197	-388	-	-205	-
		1979	109	-74	-	109	-
		1980	681	506	-	949	-
		1981	303	268	-	345	-
		1982	202	-19	-	248	-
		1983	745	-	719	-	796
Diammonium phosphate	330	1977	315	-368	-	-177	-
		1978	225	259	-	336	-
		1979	555	587	-	665	-
		1980	1,135	1,185	-	1,262	-
		1981	804	864	-	941	-
		1982	1,742	1,810	-	1,877	-
		1983	2,797	-	2,874	-	2,952
Triple superphosphate	170	1977	-49	-222	-	-39	-
		1978	200	30	-	213	-
		1979	359	195	-	378	-
		1980	634	596	-	673	-
		1981	399	364	-	441	-
		1982	202	161	-	238	-
		1983	618	-	590	-	- 667
Triple superphosphate	330	1977	17	-32	-	107	-
		1978	272	299	-	376	-
		1979	440	473	-	550	-
		1980	33	47	-	148	-
		1981	601	647	-	724	-
		1982	1,173	1,224	-	1,301	-
		1983	1,978	-	2,037	-	2,114

2. Capital availability

Companies in the fertilizer industry which are diversified and integrated will experience little difficulty in financing the incremental investment in pollution control. Except for the ion exchange process for ammonium nitrate, the capital outlays are not proportionally large compared to original investment.

Cash flows and capital structures are both favorable for raising funds. It would appear that internally generated funds, plus some borrowing, can adequately cover most required capital outlays.

For companies which are not diversified and which have small plants, one can foresee some difficulty. In the phosphate segment, where earnings may be severely depressed in 1975 and 1976, small companies without diversification will probably be hardpressed to finance pollution control investment. Internal funding will not be generally available and such companies will not be very good credit risks.

It is not possible to apply these generalizations to specific companies and plants. Financial data are simply not available for such analysis.

C. Production Effects

Of real and fundamental interest is the production impact which introduction of BPT and BAT effluents controls may cause. Of particular interest are potential plant closures. As discussed in Chapter IV, the methodology used was the use of an economic shutdown model or model plant data, comparison of these results with plants in the fertilizer industry and the drawing of inferences regarding closure for each based on its relationship to the model and factors not reflected in the model data. In order to obtain tractable models, the fertilizer industry was characterized by specific product segments. It is recognized that many multi-product complexes do exist and that the economics of these complexes may not be fully reflected in the building block models employed in this analysis. However, it is DPRA's opinion that the building block economics do not greatly differ from those found in the complex situation and that use of this procedure will produce useable and reasonable conclusions.

1. Potential Plant Closures

The underlying model plant financial parameters relating to the closure analysis are shown in Table VI-4 above. These data reflect expected price changes for the conditions of effluent control.

Net present values, computed at 6.0 and 7.0 percent after tax cost of capital, present a long run view of future financial performance, since they include returns over time and replacement investment as well as a measure of the efficiency of capital use. In interpreting net present values (NPV) in Table VI-4, values less than zero indicate that the firm would be financially better off by liquidating the sunk investment and reinvesting where that money could yield the firm's target return on capital.

The smallest units shown for all three nitrogen products show significant negative NPV's indicating closure. It should also be noted that, excepting ammonium nitrate, these units also have significant negative NPV's in the base condition. The negative NPV's suggest that returns are not sufficient to sustain a facilities replacement and modernization program.

In the phosphate component, the small DAP plant with no liming in place has a significant negative NPV under conditions of effluent control.

The model plants do not fit actual plants exactly, so these results must be interpreted in light of what is known about actual plants. Unfortunately a serious deficiency exists regarding the amount of pollution control in place. As indicated in Chapter V, it was assumed that none was in place in the nitrogen segments and that one-half of the phosphate plants had double liming in place. None were assumed to be using triple liming technology. Factors considered in the closure analysis, other than the capacity-return relationships, included known industrial uses of products and association with integrated multi-product complexes. This latter item was weighted heavily in evaluating the phosphate plants where much of the effluent control system is common to all the complex and is purportedly not a direct function of plant size. The deficiency of not knowing in-place pollution control in the phosphate segment presented a difficult problem. This was handled by estimating ranges of closures, whereby the high probability of closure estimate was based on the assumption of double liming in place and the maybe estimate on no liming in place.

In general, the expected closures are the smaller plants and generally single plant or simple multiplant complexes.

The results of this evaluation of potential closures are displayed in Tables VI-6 and VI-7. The first condition shown was the baseline closures. These estimates purport to show normal attrition due to

Table VI-6. Projected number of plant closures due to effluent controls

		Base		BPT only		BPT & BAT	
		No.	Pct. 1/	No.	Pct. 1/	No.	Pct. 1/
Ammonia	Minimum	1	1.2	1	1.2	1	1.2
	Maximum	10	12.0	3	3.6	3	3.6
Ammonium nitrate	Minimum	2	3.7	12	22.2	16	29.6
	Maximum	7	13.0	24	44.4	29	53.7
Urea	Minimum	1	2.4	2	4.8	2	4.8
	Maximum	3	7.1	10	23.8	12	28.6
Ammonium phosphate	Minimum	0	0.0	5	12.2	5	12.2
	Maximum	9	22.0	18	43.9	18	43.9
Triple superphosphate	Minimum	0	0.0	1	6.7	1	6.7
	Maximum	0	0.0	3	20.0	3	20.0

1/ Of segment

Table VI-7. Projected capacity of plant closures due to effluent controls

Range		Base		BPT only		BPT + BAT	
		1000 tons	Pct. 1/	1000 tons	Pct. 1/	1000 tons	Pct. 1/
Ammonia	Minimum	178	1.1	55	.3	55	.3
	Maximum	241	1.4	118	.7	118	.7
Ammonium nitrate	Minimum	38	.5	828	11.5	1,215	16.9
	Maximum	278	3.9	1,745	24.3	2,427	33.7
Urea	Minimum	55	1.3	85	1.9	85	1.9
	Maximum	110	2.5	372	8.5	466	10.7
Ammonium phosphate	Minimum	0	0.0	345	9.3	345	9.3
	Maximum	316	8.6	1,051	28.6	1,051	28.6
			(5.7) 2/		(19.1) 2/		(19.1) 2/
Triple superphosphate	Minimum	0	0.0	41	2.2	41	2.2
	Maximum	0	0.0	197	10.5	197	10.5

1/ Of segment.

2/ Based on projected capacity.

operating conditions, before imposition of pollution control. The next condition represents estimated probability of closures under an alternative of BPT only. The third condition reports estimates of closures under BPT and BAT. Potential closures were reported as high probability, maybe and low. These basic estimates were arranged into ranges which are reported in Tables VI-6 and VI-7.

Adjusting out the estimated baseline closures, the most serious impact on plant closures is in the ammonium nitrate and diammonium phosphate segments where 12 to 24 percent and 9 to 29 (or 19 percent based on expected new capacity) of the respective capacities are projected to close due to effluent controls. Each of the products is briefly discussed below.

In the ammonia sector, less than one percent of the capacity (one to four percent of the plants) is projected to close due to effluent control. This compares to about one percent of capacity (one to 12 percent of the plants) projected to close under the baseline condition. It is interesting to note that during the past year, three smaller units have ceased operations.

Ammonium nitrate plants may be particularly hard hit due to the large number of small plants and the high cost of pollution controls. Also, they cannot pass on the full incremental pollution costs in the form of higher prices. Net of baseline closures, 12 to 24 percent of the capacity (22 to 44 percent of the plants) is expected to close. It is recognized that prices for nitrogen products will strengthen over the next few years, but as stated in the introduction of this Chapter, operating margins are not expected to proportionately improve, due to increasing operating costs. In evaluating closures of ammonium nitrate plants, it should be noted that ammonia represents both a primary direct application fertilizer and a feedstock for urea and ammonium nitrate. With the proportionately higher pollution control costs involved in ammonium nitrate production, it seems likely that ammonia would be marketed in increasing quantities as direct application materials or as urea feedstocks, where the profit margin would be greater than in ammonium nitrate. As pointed out in the preceding discussion of price impacts, it seems unlikely that the full cost of pollution controls in ammonium nitrates can be passed on, since this action would upset price relationships with urea, to a point where urea would be much more competitive.

Although potential urea capacity and plant closings are higher than the ammonia segment, they are significantly lower than the ammonium nitrate segment. Closure due to pollution control (BPT and BAT) ranges from 2 to 11 percent of the capacity (5 to 29 percent of the plants).

As suggested earlier, estimates of plant closings in the ammonium phosphate segment are complicated by the expected deterioration of prices and profits due to increased industry capacity as discussed in Chapter III. The estimated economics suggest that a number of plants would close in face of declining prices. However, most plants remained open during the low prices and negative returns experienced during the late 1960's. This suggests that the industry is willing to withstand these losses, apparently on the expectation of the return of higher prices and profits. It is generally noted that the industry places considerable emphasis on maintaining market share, which also explains this sort of action. Thus, the baseline estimate of closure is from zero to six percent of capacity (zero to 22 percent of the plants). Imposition of effluent control technology is projected to result in closure of 9 to 19 percent of capacity. Because of possibility of already in-place double liming facilities, the upper range could be reduced since some or all of the potentially closed plants may have this technology. However, it seems likely that these smaller units would be less likely to have double liming than the larger units.

Closure projections in the phosphate segments are predicated on the projection of substantially increased industry capacity coming on stream by 1973 to 1977. As previously discussed, this projection is based upon reported industry intentions for new construction. Although this construction could be delayed, it does represent firm plans for expansion.

There are six small units with 130,000 tons capacity that produce special ammonium phosphate type of products or N-P-K grades. These units were not included in the closure estimates, since it is not known whether or not the pollution control costs provided by EPA are applicable. Should the costs be similar, it is likely that these plants would also close. However, the tonnage involved is not large.

Triple superphosphate plants would appear to be in a better position with only two to 10 percent of the capacity potentially impacted. This estimate was based on a downward extrapolation of the model plant data and the potential closures include only the very small units - under 40,000 tons per year.

2. New Source Performance Standards

New facilities on line after approximately January 1, 1974, must meet the Best Available Technology standards for direct discharge into navigable waters. In analyzing the impact of NSPS on the industry, it has been necessary to make certain assumptions about new facilities.

In the nitrogen segment, the contractor has learned of one new ammonia plant announcement. Because of general uncertainty, it is reasonable to expect further expansion to be delayed. It is doubtful that new capacity will be on line before 1975 or 1976. We have therefore used 1977 as the base year of operations for price and cost data used in the impact analysis. Investment costs, prices and operating costs are expressed in 1972 dollars; operating costs have been adjusted to reflect anticipated real cost increases because of shifting supply-demand relationships.

We have further assumed that only large plants will be constructed in the near future and that these will operate at 90 percent of capacity. Sales revenues are based on the estimated new price levels in 1977 and 1983 which include the estimated change in prices resulting from BPT and BAT effluent controls.

Different assumptions have been made for the phosphate segment. As indicated earlier, overcapacity and falling prices after 1973 will probably occur. We have estimated changing price levels in each year through 1983, after which we assume constant prices. Costs were retained at the 1972 level.

In evaluating BPT impact, we assumed that existing plants would cut costs as much as possible during the years of depressed prices. For newly opened facilities, it is doubtful that operating costs will be reduced; therefore, we have assumed that new plants, if opened, will probably operate at cost ratios similar to the model plants presented in Chapter II. A breakthrough in technology could, of course, change expense ratios.

For both segments, we assumed one half of the capital investment in the first year and one half in the second year with operating proceeds starting in the third year. Working capital, equal to 10 percent of sales, has been provided in the third year.

The analysis also includes the assumption that there will be no replacement of plant. Salvage values are estimated at 8 percent of original cost plus net working capital.

Table VI-8 presents cash flows and net present values for model plants without and with NSPS effluent controls. In the nitrogen segment, all producers would have lower cash flows and net present values with NSPS included; but with positive net present values, it is likely that plants such as these would be built.

Diammonium phosphate and triple superphosphate plants show negative present values both without and with NSPS controls, except for the super large (720,000 TPY) DAP plant. Since NSPS makes the present values much more negative for the 330,000 TPY DAP and TSP plants, one could reasonably expect delays in construction of any new DAP and TSP plants in this size range. With the higher prices expected in the early 1980's, such plants could be profitable again as they are in 1973. The very large DAP plants for which commitments are already existing are expected to proceed with construction.

3. Production Curtailment

Although capacity reduction for all segments, excepting ammonium nitrate and DAP, is relatively small, it is conceivable that production curtailment might occur, particularly in the nitrogen products area in the sense that sufficient new capacity to meet demand will not be built. NSPS effluent technology of itself is not expected to limit new construction for these products; uncertainty about an actual natural gas shortage may limit new construction. Further, if such shortages limit profit margins as postulated, plant closures due to pollution control could have a curtailing effect on production relative to the quantity the market would take.

Potentially closed capacity of ammonium phosphate plants should not significantly curtail production as it appears there will be sufficient capacity to absorb the lost production.

D. Employment Effects

Being capital intensive, the segments of the fertilizer industry studied here employ few people relative to sales. Based upon labor requirements for production and plant supervision, the following estimate of job losses and an indication of the order of magnitude of lost payroll is given.

Table VI-8. Estimated annual cash proceeds and net present values for model plants without and with NSPS effluent controls with expected price adjustments

		Without controls				With controls			
		Cash proceeds		Net present value		Cash proceeds		Net present value	
Model plant	Capacity	Period I	Period II	6.0	7.0	Period I	Period II	6.0	7.0
	000 TPY	--------------------$000----------------				----------------$000--------------			
Ammonia	350	3,548	3,619	7,069	4,715	3,442	3,478	5,398	3,149
	525	5,451	5,556	17,776	14,153	5,316	5,370	15,617	12,132
Ammonium nitrate	350	3,710	3,751	11,357	8,902	3,436	3,478	7,303	5,084
Urea	350	4,713	4,767	15,804	12,682	4,578	4,631	13,717	10,714
DAP	330	1/	4,966	(5,754)	(7,660)	1/	4,483	(12,120)	(13,871)
	720	1/	12,284	11,173	6,303	1/	12,099	10,579	5,685
TSP	330	1/	3,159	(1,167)	(5,308)	1/	3,040	(6,721)	(7,745)

1/ Varies by year.

	Range	Reduction--BPT		Reduction-- BPT + BAT	
		Jobs	Payroll ($1,000)	Jobs	Payroll ($1,000)
Ammonia	Minimum	20	240	20	240
	Maximum	50	600	50	600
Ammonium nitrate	Minimum	300	3,600	400	4,800
	Maximum	600	7,200	800	9,600
Urea	Minimum	75	900	75	900
	Maximum	335	4,020	420	5,040
Ammonium phosphate	Minimum	85	1,020	85	1,020
	Maximum	250	3,000	250	3,000
Triple superphosphate	Minimum	10	120	10	120
	Maximum	50	600	50	600
Total	Minimum	490	5,880	590	7,080
	Maximum	1,285	15,420	1,570	18,840

As shown above, the estimated total job losses range from 490 to 1,285 at the BPT level, representing a payroll of $5.9 to $15.4 million. BAT adds an estimated loss of 100 to 285 jobs and $1.2 to $3.4 million payroll. The BPT plus BAT job losses range from 590 to 1,570, with a payroll reduction of $7.1 to $18.8 million.

Possibilities for reemployment in other plants would not appear likely and the displaced workers would have to be absorbed into other industries since few new plants are expected, plus the fact that any new plants will likely be very large, highly automated units.

Secondary impacts on employment are not expected to be significant, since supporting activities, i.e., transportation suppliers, would likely direct their activities to other fertilizer plants and economic activity.

E. Community Impacts

Impacted fertilizer plants are dispersed throughout the United States and plant closures are not expected to greatly impact any single area. A single plant closure could represent up to 40 jobs in a single community. Such a loss could reduce the economic base of the community by $1.2 million assuming a multiplier of 2.5. An inspection of the location of potentially impacted plants indicates that plants often are physically located in communities of under 50,000 but that these locations are often near or a part of a larger industrial area.

Although community impacts will likely be important to the community involved, there does not appear to be any significant geographical concentration of closures.

F. Balance of Payments Effects

As shown in Chapter III, the United States exported 18.8 million tons of fertilizer materials of which phosphate rock represented 13.6 million tons. The contribution of fertilizer exports to United States foreign exchange has been as follows:

Year	Fertilizer Exports ($ million)
1969	370.5
1970	308.9
1971	288.6
1972	339.0

The product segments on which this study reports in the main have a positive trade balance (see Table VI-9), but ammonia and urea demonstrate a narrowing of the balance. Ammonium nitrate, on the other hand, shows a growing negative trade balance, while ammonium phosphate shows a growing favorable trade balance. These products constitute the majority of the U.S. exports in fertilizer materials, excepting phosphate rock.

The expected price increases due to effluent controls are small in relation to normal swings in the export price (for instance the DAP export price was $80 to $100 per ton in late 1972 compared to $50 to $60 per ton in 1971). However, it seems probable that this may exert a further dampening effect on exports, particularly when taken with limited or

Table VI-9. Foreign trade balance of selected fertilizer materials in 1,000 tons

Products	1970			1971			1972		
	Exports	Imports	Balance	Exports	Imports	Balance	Exports	Imports	Balance
Ammonia	764	477	287	598	501	97	421	392	29
Ammonium nitrate	81	306	-225	59	366	-307	34	390	-356
Urea	670	422	248	374	330	44	464	365	99
Concentrated superphosphate	711	NR	-	627	NR	-	924	NR	-
Ammonium phosphate	986	395	591	1,135	472	663	1,542	488	1,054

uncertain natural gas supplies. It is expected that in the case of ammonium nitrate, the imposition of effluent controls will accentuate an already negative trade balance in this product.

It is concluded that effluent controls will likely serve to contribute to a loss of export markets, but, with the possible exception of ammonium nitrate, further loss will be primarily due to other factors.

VII. LIMITS TO ANALYSIS

A. General Accuracy

Data gathered were of a secondary nature, drawn from published reports of the USDA, TVA, National Plant Food Institute, annual company reports, financial statistics services and private sources.

Throughout the study, an effort was made to evaluate and cross check the data and other information used and to update these materials wherever possible. Checks were made with informed sources in industry and government to help insure that data and information used were as reliable and as representative as possible. For example, plant investment costs were checked with several fertilizer engineering firms. Costs were reviewed with contacts with the various companies.

It is believed that the data generally reflect conditions in the industry and that the methodology used provides the basis to systematically evaluate the impact of increased water pollution controls on the fertilizer industry. However, with the many plant complexes, plant to plant variance is likely.

B. Possible Range of Error

Specifications of the contract required the Contractor to use effluent control costs as provided by EPA and thus, comment on these costs by the Contractor is not appropriate. Different data series and different sections of the analysis will have varying possible ranges of error. Estimated error ranges as an order of magnitude are as follows:

		Error Range (pct)
1.	Number, and location of facilities	±1.0
2.	Capacity, age, processes of plants	±5.0
3.	Price information for products and raw materials	±15.0
4.	Sunk investment value	±20.0
5.	Plant operating costs	±10.0
6.	Water pollution control costs	Not estimated
7.	Plant closures	±35.0

Given the basic effluent control costs, some error may occur in estimating these costs for the model plants due to the method of using the base cost data. For purposes of this analysis, the nitrogen product effluent costs were estimated on a building block basis. This procedure assumed that control facilities will be sized and attached to each component. In practice it seems likely that some plants will be able to use a common treatment facility for all components in a complex. Given the size-cost relationships in this technology, use of a common treatment facility would be less costly on a unit basis than summing individual treatment units. After discussion with EPA, it was concluded that the building block procedure would be a fairer and more reasonable estimate, since many plants may not be able to use common facilities.

It should also be noted that much of the effluent investment and operating costs for the phosphate segment were reported to be independent of plant size. The effect of this is that small plants have proportionately higher unit control costs. In practice it seems probable that small plants may be able to achieve some savings in absolute outlays and O&M costs over large plants, thus reducing their unit costs. To the extent this is possible, these costs have been overestimated.

C. Critical Assumptions

In any analysis of this sort, a number of underlying assumptions are required. Some of the more critical assumptions used in this analysis are given below.

1. All plants within a product and size segment were assumed to have similar manufacturing costs and salvage values. No doubt variations will occur due to locational advantages, association with complexes and market outlets (possible industrial sales in addition to fertilizers).

2. Process chemical intermediates (ammonia, nitric acid, sulfuric acid, phosphoric acid) were assumed to be self-produced and taken at cost with appropriate prorates. In reality, raw material and intermediate products inputs will vary in cost by company in accordance with proximity to raw materials sources, ability to self produce, size of the unit for self-produced materials, and unique purchasing arrangements.

3. All end-product plants were treated individually without consideration to an almost infinite number of combinations of different plants by product. These many multi-end-product complexes have possibilities for savings through joint service facilities (water, power, cooling), labor, supervision, plant overhead, etc.

4. All plants within the same industry segment will operate at equal capacity utilization rates.

5. Prices and plant netbacks were generally assumed to be uniform for plants in each segment (excepting the two small ammonia plants which were assumed to have higher prices) -- graduated only by plant size to compensate for differences in distribution distances (freight equalization costs).

6. Sales, general and administrative costs were assumed to be similar for all plants within an industry segment.

7. A key assumption (projection) in the analysis of the phosphate segment was that announced DAP plant construction would occur and that the projected capacity would be realized.

8. From this assumption, we have projected price declines through 1977 followed by gradual improvement. This is also predicated on the notion that the industry will respond as it did in the late 1960's as an immature oliogopoly. This serves to greatly depress profitability in the phosphate segment.

9. Given this situation, it was further assumed that phosphate industry management would respond in the short run by deferring maintenance and replacement investment and reducing sales, general and administrative expenses, rather than make immediate across the board closures.

10. It was assumed that new competitive feedstocks for ammonia production would not be forthcoming and that natural gas would become available on an interruptible basis. It was further assumed that any price improvement due to tight nitrogen supplies would be offset by increased costs of natural gas and for lower utilization rates resulting in a constant operating margin.

11. Both solution and prilled forms of ammonium nitrate and urea were assumed to have the same manufacturing and effluent control costs. It may be that solution forms will have a cost advantage because they are produced in a simpler process.

D. Remaining Questions

Because the products studied in this analysis are the primary fertilizer building blocks for most other fertilizer products, exclusion of the other products is not believed to be serious. However, it may be possible that effluent controls on end-use products will place them at a more serious price disadvantage, thus improving the market for basic materials as direct application materials. This, of course, remains to be determined.

A major question concerns the phosphate industry and its projected new capacity and its response to this excess capacity. The projections in this report represent the best information available and DPRA's interpretation of this information. In this case only developments over time can lead to resolution of this question.

In the nitrogen segment, a major question revolves around future feedstock sources. Rapid development and utilization of new sources of natural gas (for example, Alaskan) and/or the import of large quantities of liquid natural gas could hasten plant closures or extend closures to intermediate plant sizes in present locations as new, larger plants are built nearer the new gas sources. A severe shortage of and substantial increase in the price of natural gas could result in a restructuring of the nitrogen industry. This could lead to the utilization of alternative feedstocks (i.e., coal, off-gas) for nitrogen production or the use of imported feedstocks.

Another related question is the rate of development of overseas nitrogen and phosphate manufacture. Foreign development, particularly of lower cost producers, could significantly reduce U.S. exports and thereby increase the U.S. domestic supply through loss of export markets. This could lead to further price weakening, particularly in the phosphate area. Development of overseas producers coupled with ammonia feedstock shortages and/or high prices could conceivably, along with effluent controls, create a condition where fertilizer imports would cost less than domestic supplies. If this were to happen, further closures of U.S. capacity would be expected. Answers to this issue would require a world wide study of new fertilizer manufacturing and the future feedstock situation regarding prices and technology.

APPENDIX A

Direct and Indirect Cost Data for Model Fertilizer Plants

A

Table A-1. **Estimated direct and indirect expenses and costs for anhydrous ammonia plants**

			Annual capacity (TPY)									
			50,000		105,000		210,000		350,000		525,000	
Product related expenses	Units	$/unit	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton
Natural gas	MSCF	0.31 1/	28.6	$13.16	28.6	$13.16	31.5	$ 9.76	31.5	$ 9.76	31.5	$ 9.76
Power	kwh	.009	600	5.40	600	5.40	20	.18	20	.18	20	.18
Boiler feed water	1000 lbs	.05	3	.15	3	.15	4	.20	4	.20	4	.20
Cooling water makeup	1000 gals	.15	2.1	.32	2.1	.32	2.5	.38	2.5	.38	2.5	.38
Catalyst and chemicals				.85		.85		.90		.90		.90
Operating labor	man hrs.	4.50	.50	2.25	.32	1.44	.16	.72	.12	.54	.096	.43
Supervision and fringe benefits	operating labor	100%		2.25		1.44		.72		.54		.43
Total				$24.38		$22.76		$12.86		$12.50		$12.28
Plant related expenses			Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)
Maintenance and supplies 2/	4% of investment		$5,500	$220	$8,000	$ 320	$12,000	$ 481	$19,000	$ 760	$24,000	$ 961
Taxes and insurance 2/	3% of investment		$5,500	$165	$8,000	$ 240	$12,000	$ 360	$19,000	$ 570	$24,000	$ 720
Plant and labor overhead	100% of production labor times thruput		$4.50	$225	$2.88	$ 302	$1.44	$ 302	$1.08	$ 378	$.86	$ 452
Sales, general and administrative	15% of sales		$2,050	$308	$4,305	$ 646	$6,510	$ 977	$10,850	$1,628	$16,275	$2,441
Total				$918		$1,508		$2,120		$3,336		$4,575
Depreciation 3/												
Ammonia			$4,013	$201	$5,800	$ 290	$8,550	$513	$13,325	$ 933	$16,800	$1,176
Interest	1.5% of sales		$2,050	$ 31	$4,305	$ 63	$6,510	$ 98	$10,850	$ 163	$16,275	$ 244

1/ Unit natural gas price for 50,000 and 105,000 ton plants estimated at $.46 per MSCF

2/ Percentages are based on battery limits plant investment.

3/ Percentages are 5, 5, 6, 7 and 7; basis is 50 percent of total investment to approximate book value.

Table A-2. Estimated direct and indirect expenses and costs for nitric acid.

			Annual capacity (TPY)					
			85,000		130,000		285,000	
Product related expenses	Units	$/unit	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton
Ammonia[1]	tons	12.86	.292	$3.76	.292	$3.76	.292[2]	$3.65
Power	kwh	.009	10	.09	10	.09	10	.09
Catalyst [3]	grams	4.00	.12	.48	.12	.48	.12	.48
Water[4]	m-gal.	.05	40	2.00	40	2.00	40	2.00
Operating labor	men-shift	--	2	.89	2	.58	2	.27
Supervision and fringes	operating labor	100%		.89		.58		.27
Total				$8.11		$7.49		$6.76
Plant related expenses			Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)
Maintenance and supplies	4% of investment		$3,400	$136	$4,250	$170	$6,500	$260
Taxes and insurance	3% of investment		$3,400	$102	$4,250	$128	$6,500	$195
Plant and labor overhead	100% of production labor		$1.78	$151	$1.16	$151	$.54	$154
Sales, general and administration	(in end product)			--		--		--
Subtotal				$389		$449		$609
Ammonia prorate	12, 18 and 23% respectively		$2,120	$254	$2,120	$382	$3,336	$767
Total				$643		$831		$1,376
Depreciation								
Nitric acid	8% of av. investment		$1,700	$136	$2,125	$170	$3,250	$260
Ammonia prorate	12, 18 and 23% respectively		$ 513	$ 62	$ 513	$ 92	$ 933	$215
Total				$198		$262		$475
Interest								
Nitric acid	(in end product)							
Ammonia prorate	(12, 18 and 23% respect-		$ 98	$ 12	$ 98	$ 18	$ 163	$ 37
Total				$ 12		$ 18		$ 37

[1] Assumes 93.5% recovery [2] .292 x $12.50 [3] Assumes 40% recovery [4] Excludes boiler and process water

Note: Costs based on whole high pressure process. Excludes steam credit of 300 pounds/ton of product.

Table A-3. Estimated direct and indirect expenses and costs for ammonium nitrate

Product related expenses	Units	$/unit	Annual capacity (TPY) 105,000 Units/ton	105,000 $/ton	160,000 Units/ton	160,000 $/ton	350,000 Units/ton	350,000 $/ton
Ammonia	tons		($12.86) .217	2.79	($12.86) .217	2.79	($12.50) .217	2.71
Nitric acid	tons		($8.11) .803	6.51	($7.49) .803	6.01	($6.76) .803	5.43
Power	kwh	.009	41	.37	41	.37	41	.37
Water	m-gal	.05	7.5	.38	7.5	.38	7.5	.38
Fuel	MSCF	.31	2.3	.71	2.3	.71	2.3	.71
Diatomaceous earth	ton	50.00	.03	1.50	.03	1.50	.03	1.50
Operating labor	Men/shift	--	4	1.44	4	.96	4	.43
Supervision and operating labor	operating labor	100%	--	1.44	--	.96	--	.43
				$15.14		$13.68		$11.96
Plant related expenses			Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)
Maintenance and supplies	4% of investment		$2,350	$ 94	$3,100	$ 124	$5,100	$ 204
Taxes and insurance	3% of investment		$2,350	$ 70	$3,100	$ 93	$5,100	$ 153
Plant and labor overhead	100% production labor times thruput		$2.88	$ 302	$1.92	$ 307	$.86	$ 301
Sales, general and administration	15% of sales		$4,305	$ 646	$6,560	$ 984	$14,350	$2,153
Subtotal				$1,112		$1,508		$2,811
Ammonia prorate	11, 17, and 22% respectively		$2,120	$ 233	$2,120	$ 360	$3,336	$ 734
Nitric acid prorate	100%		643	643	831	831	1,376	$1,376
Total				$1,988		$2,699		$4,921
Depreciation								
Ammonium nitrate[1/]			$1,175	$ 71	$1,550	$ 109	$2,550	$ 204
Ammonia prorate	11, 17 & 22% respectively		$ 513	$ 56	$ 513	$ 87	$ 933	$ 205
Nitric acid prorate	100%		$ 198	$ 198	$ 262	$ 262	$ 475	$ 475
Total				$ 325		$ 458		$ 884

Table A-3. (continued)

Product related expenses	Units	$/unit	Annual capacity (TPY) 105,000 Units/ton	105,000 $/ton	160,000 Units/ton	160,000 $/ton	350,000 Units/ton	350,000 $/ton
Interest								
Ammonium nitrate	1.5% of sales		$4,305	$ 65	$6,560	$ 98	$14,350	$215
Ammonia prorate	11, 17 & 22%	respectively	98	11	98	17	163	36
Nitric acid prorate	100%		12	12	18	18	37	37
Total				$ 88		$133		$288

1/ Rates are 6, 7 and 8 percent; basis is 50 percent of battery limits plant investment.

Table A-4. Estimated direct and indirect expenses and costs for urea

			Annual capacity (TPY)							
			52,000		105,000		160,000		350,000	
Product related expenses	Units	$/unit	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton
Ammonia	tons		(22.76) .61	13.88	(12.86) .61	$ 7.84	($12.50) .61	$ 7.62	$12.28) .61	$ 7.49
Carbon dioxide	tons	0.00	.75	--	.75	--	.75	--	.75	--
Oil	gal.	.25	3	.75	3	.75	3	.75	3	.75
Electric power	kwh	.009	190	1.71	190	1.71	190	1.71	190	1.71
Fuel gas	MSCF	.31	9.7	3.01	9.7	3.01	9.7	3.01	9.7	3.01
Water	m-gal.	.05	17	.85	17	.85	17	.85	17	.85
Clay	tons	50.00	.02	1.00	.02	1.00	.02	1.00	.02	1.00
Operating labor	men/shift		5	3.60	6	2.15	6	1.44	6	.65
Supervision and fringe benefits	operating labor	100%		3.60		2.15		1.44		.65
Total				$28.40		$19.46		$17.82		$16.11
Plant related expenses			Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)
Maintenance and supplies	4% of investment		$5,000	$ 200	$6,750	$ 270	$8,600	$ 344	$14,500	$ 580
Taxes and insurance	3% of investment		$5,000	$ 150	$6,750	$ 202	$8,600	$ 258	$14,500	$ 435
Plant and labor overhead	100% of production labor		$7.20	$ 374	$4.30	$ 451	$2.88	$ 461	$1.30	$ 455
Sales, general and administrative	15% of sales		$2,704	$ 406	$5,460	$ 819	$8,320	$1,248	$18,200	$2,730
Subtotal				$1,130		$1,742		$2,311		$4,200
Ammonia prorate	30,30,28,41% respectively		$1,508	$ 452	$2,120	$ 636	$3,336	$ 934	$4,574	$1,875
Total				$1,582		$2,378		$3,245		$6,075
Depreciation										
Urea 1/	8% of investment		$2,500	$ 150	$3,375	$ 236	$4,300	$ 301	$ 7,250	$ 580
Ammonia prorate	30,30,28,41% res.		$ 290	$ 87	$ 513	$ 154	$ 933	$ 261	$ 1,176	$ 482
Total				$ 237		$ 390		$ 562		$1,062
Interest										
Urea	1.5% of sales		$2,704	$ 41	$5,460	$ 82	$8,320	$ 125	$18,200	$ 273
Ammonia prorate	30,30,28,41% resp.		$ 65	$ 20	$ 98	$ 29	$ 163	$ 46	$ 244	$ 100
Total				$ 61		$ 111		$ 171		$ 373

1/ Rates are 6, 7, 7 and 8 percent; basis is 50 percent of battery limits plant investment.

Table A-5. Estimated direct and indirect expenses and costs for sulfuric acid

			Annual capacity (TPY)	
			235,000	
Product related expenses	Units	$/unit	Units/ ton	$/ton
Sulfur	ton	$28.00	.333	$9.32
Water	m-gals	.05	6	.30
Power	kwh	.009	8	.07
Operating labor	men/shift		2	.32
Supervision and fringe benefits	operating labor	100%		.32
				$10.33
Plant related expenses			Basis	$/yr (1,000)
Maintenance and supplies	6% of investment		$2,600	$ 156
Taxes and insurance	3% of investment		$2,600	$ 78
Plant and labor overhead	100% of production labor times thruput		$.64	$ 150
Sales, general and administrative	(in end product)			
Total				$ 384
Depreciation	10% of av. investment		$1,300	$ 130
Interest	In end product .		--	---

Note: No steam credit taken (1.1 tons H.P. steam/ton H_2SO_4)

Table A-6. Estimated direct and indirect expenses and costs for phosphoric acid

			Annual capacity (TPY)									
			50,000		83,000		200,000		300,000		340,000	
Product related expenses	Units	$/unit	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton
Phosphate rock (68 BPL)	tons	6.50	3.48	$22.62	3.48	$22.62	3.48	$22.62	3.48	$22.62	3.48	$22.62
Sulfur	tons	28.00	.90	25.20	.90	25.20	.90	25.20	.90	25.20	.90	25.20
Water	m-gal	.05	14.5	.72	14.5	.72	14.5	.72	14.5	.72	14.5	.72
Steam	m-lbs	self supplied	4.6	--	4.6	--	4.6	--	4.6	--	4.6	--
Power	kwh	.009	200	1.80	200	1.80	200	1.80	200	1.80	200	1.80
Defoaming	--	$.50	1	.50	1	.50	1	.50	1	.50	1	.50
Gypsum disposal	--	.50	1	.50	1	.50	1	.50	1	.50	1	.50
Rock grinding and handling	tons rock	1.04	3.48	3.62	3.48	3.62	3.48	3.62	3.48	3.62	3.48	3.62
Operating labor	men/shift		7	5.00	7	3.00	7	1.25	7	.83	7	.72
Supervision	men/shift		4	1.20	4	.72	4	.26	4	.17	4	.12
Fringes	operating labor	80%		4.00		2.40		1.00		.66		.58
Total				$65.16		$60.08		$57.47		$56.62		$56.40
Total (54% P_2O_5)				$35.19		$32.44		$31.03		$30.57		$30.46
Plant related expenses			Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)
Maintenance and supplies	6% of investment		$7,000	$ 420	$9,700	$ 582	$15,800	$ 948	$21,200	$1,272	$23,300	$1,398
Taxes and insurance	3% of "		$7,000	$ 210	$9,700	$ 291	$15,800	$ 474	$21,200	$ 636	$23,300	$ 699
Plant and labor overhead	100% of production labor times thruput		$10.20	$ 510	$6.12	$ 508	$2.51	$ 502	$1.66	$ 498	$1.44	$ 490
Sales, general and administrative	(in end product)			--		--		--		--		--
Total				$1,140		$1,381		$1,924		$2,406		$2,587
Depreciation 1/			$4,500	$ 315	$6,250	$ 438	$10,150	$ 812	$13,600	$1,224	$15,000	$1,350
Interest	(in end product)			--	--	--	--	--	--	--	--	--

Note: Requirements for both phosphoric and sulfuric acid.
1/ Rates are 7, 7, 8, 9, and 9 percent; basis is 50 percent of total investment. a-7

Table A-7. Estimated direct and indirect expenses and costs for DAP

Product related expenses	Units	$/unit	Annual capacity (TPY) 170,000 Units/ton	 170,000 $/ton	 330,000 Units/ton	 330,000 $/ton	 720,000 Units/ton	 720,000 $/ton
Phosphoric acid (54% P_2O_5)	tons		($32.44) .87	28.22	($31.03) .87	27.00	($30.46) .87	26.50
Ammonia 1/	tons		(24.38) .23	5.61	(22.76) .23	5.23	(12.86) .23	2.96
Power	kwh	.009	20	.18	20	.18	20	.18
Fuel oil	gal	.07	3	.21	3	.21	3	.21
Operating labor	men-shift		2	.42	2	.30	2	.21
Supervision and fringe benefits	operating labor	100%	--	.42	--	.30	--	.21
Total				35.06		33.22		30.27
Plant related expenses			Basis	$/yr (1,000)	Basis	$/yr (1,000)	Basis	$/yr (1,000)
Maintenance and supplies	6% of investment		$3,100	186	$4,900	294	$8,750	525
Taxes and insurance	3% of investment		$3,100	93	$4,900	147	$8,750	262
Plant and labor overhead	100% of production labor times thruput		$.84	143	$.60	198	$.42	302
Sales, general and administrative	15% of sales		$11,220	$1.683	$21,780	$3,267	$47,520	$7,128
Subtotal				$2,105		$3,906		$8,217
Ammonia prorate	78, 72 & 78% respectively		$ 918	716	$1,508	$1,086	$ 2,120	$1,654
Phosphoric acid prorate	100, 78 & 100% "		$1,381	$1,381	$1,924	$1,501	$ 2,587	$2,587
Total				$4,202		$6,493		$12,458
Depreciation								
DAP	10% of investment		$1,550	155	2,450	245	$4,375	$ 438
Ammonia prorate	78, 72 & 78% respectively		201	157	290	209	513	400
Phosphoric acid prorate	100, 78 & 100% "		438	438	812	633	1,350	1,350
Total				750		$1,087		$2,188

Table A-7. (continued)

Product related expaneses	Units	$/unit	170,000		330,000		720,000	
			Units/ ton	$/ton	Units/ ton	$/ton	Units/ ton	$/ton
Interest								
DAP	1.5% of sales		$11,220	$168	$21,780	$327	$47,520	$713
Ammonia prorate	78,72 & 78% resp.		$ 31	$ 24	$ 65	$ 47	$ 98	$ 76
Phosphoric acid prorate	100%		--	--	--	--	--	--
Total				$192		$374		$789

1/ Assumes 95% recovery

2/ Basis is 50 percent of battery limits plant investment.

Table A-8. Estimated direct and indirect expenses and costs for TSP

		Annual capacity (TPY)					
		170,000			330,000		
Product related expenses	Units	$ /unit	Units/ ton	$/ton	$/unit	Units/ ton	$/ton
Phosphoric acid (54% P_2O_5)	tons	$32.44	.646	$20.96	$31.03	.646	$20.05
Phosphate rock (75 BPL)	tons	9.20	.393	3.62	9.20	.393	3.62
Power	kwh	.009	25	.22	.009	25	.22
Fuel oil	gal	.07	4	.28	.07	4	.28
Rock grinding and handling	tons rock	1.04	.393	.41	1.04	.393	.41
Operating labor	men/shift		2	.42		2	.30
Supervision and fringes	operating labor	100%		.42			.30
Total				$26.33			$25.18
Plant related expenses			Basis	$/yr (1,000)		Basis	$/yr (1,000)
Maintenance and supplies	6% of investment		$3,400	$ 204		$5,374	$ 322
Taxes and insurance	3% of investment		$3,400	$ 102		$5,374	161
Plant and labor overhead	100% of production labor times thruput		$.84	$ 143		$.60	$ 198
Sales, general and administrative	15% of sales		$7,820	$1,173		$15,180	$2,277
Subtotal				$1,622			$2,958
Phosphoric acid prorate	71%, 58% respectively		$1,381	$ 981		$1,924	$1,116
Total				$2,603			$4,074
Depreciation							
TSP	10% av. investment		$1,700	$ 170		$5,374	$ 269
Phosphoric acid prorate	71%, 58% respectively		$ 438	$ 311		$ 812	$ 471
Total				$ 481			$ 740
Interest							
TSP	1.5% of sales		$7,820	$ 117			$ 228
Phosphoric acid prorate			--	--		--	--
Total	100%			$ 117			$ 228

Table A-9. Estimated direct and indirect expenses and costs for NSP

Product related expenses	Units	120 TPD 24,000 TPY $/unit	120 TPD Units/ton	120 TPD $/ton	200 TPD 40,000 TPY $/unit	200 TPD Units/ton	200 TPD $/ton	300 TPD 60,000 TPY $/unit	300 TPD Units/ton	300 TPD $/ton	400 TPD 80,000 TPY $/unit	400 TPD Units/ton	400 TPD $/ton
Phosphate rock (73 BPL)	tons	14.00 1/	.6	8.40	14.00	.6	8.40	14.00	.6	8.40	14.00	.6	8.40
Sulfuric acid (100% H_2SO_4)	tons	25.00 2/	.357	8.93	16.00	.357	5.71	16.00	.357	5.71	16.00	.357	5.71
Power	kwh	.014	20.8	.29			.29			.29			.29
Operating labor and supervision	man hrs.	4.00	.80	3.20	4.00	.48	1.92	4.00	.40	1.60	4.00	.36	1.44
Total				20.82			16.32			16.00			15.84
Plant related expenses		Basis		$000			$000			$000			$000
Maintenance and supplies		6 % of investment		35			58			77			96
Taxes and insurance		3 % of investment		18			29			39			48
Plant overhead		100 % of investment		77			77			115			154
Sales, general and administrative		15 % of sales		101			168			252			336
Sulfuric acid pro-rate		$384,000	0%	0		6%	23		9%	35		12%	46
Total				231			355			518			680
Depreciation 3/				18			26			33			40
Sulfuric acid pro-rate		$130,000	0%	0		6%	8		9%	12		12%	16
				18			34			45			56
Interest 4/				--			--			--			--

1/ Delivered price plus $.54/ton for grinding.

2/ Smallest NSP plant assumed to purchase H_2SO_4; other sizes are on site with H_2SO_4 plant.

3/ Calculated at $150, $130, $110, and $100 per daily ton of capacity for respective plant sizes.

4/ No long-term interest assumed due to age of plants; short-term interest included in S.G.A. expense.

APPENDIX B

Cost and Financial Analysis Data Relating to Alternative Pollution Control Technologies

B

Table B-1. Nitrogen--Estimated investment and annual costs for effluent control technology in fertilizer manufacturing

Nitrogen (annual capacity, 1,000 TPY)	50/52	85	105	130	160	210	285/295	340/350[1/]	525
					$1,000				
Chromate Removal									
Investment	29	38	42	46	53	58	68	76	97
Annual costs									
Material	3	5	6	8	9	12	16	20	30
Energy and power	.4	.5	.6	.6	.7	.8	1	1.1	1.4
O & M	1.2	1.5	1.7	1.8	2.1	2.3	2.7	3.0	3.9
Subtotal	4.6	7.0	8.3	10.4	11.8	15.1	19.7	24.1	35.3
Depreciation - 10 percent	2.9	3.8	4.2	4.6	5.3	5.8	6.8	7.6	9.7
Interest (7.5% x .5)	1.1	1.4	1.6	1.7	2.0	2.2	2.6	2.9	3.6
Total	8.6	12.2	14.1	16.7	19.1	23.1	29.1	34.6	48.6

Table B-2. Estimated investment and annual costs for effluent control technology in phosphate fertilizer manufacturing (continued)

Annual Capacity, 1,000 TPY	170		330[1]	720
	($1,000)		($1,000)	($1,000)
Phosphoric Acid				
H_2SO_4 dilution - pond water				
Investment	193		299	396
Annual costs				
Raw materials	-		-	-
Energy and power	12		18	24
O&M	8		12	16
Subtotal	20		30	40
Depreciation	19		30	40
Interest	7		11	15
Subtotal	26		41	55
Total	46		71	95
Chromate control				
Investment	64	76	105	143
Annual cost				
Materials	14	19	33	55
Energy and power	1	1	1	2
O&M	3	3	4	6
Subtotal	18	23	38	63
Depreciation	6	8	10	14
Interest	2	3	4	5
Subtotal	8	11	14	19
Total	36	34	52	82
DAP				
AP self-contained				
Investment	235		337	520
Annual cost				
Energy and power	259		371	572
Labor	46		46	46
O&M	9		13	21
Subtotal	314		430	639
Depreciation	24		34	52
Interest	9		13	20
Subtotal	33		47	72
Total	347		477	711

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[1] Data points provided by EPA.

Table B-3. Estimated incremental investment and annual costs for BPT and BAT effluent controls 2/ in model plants

Product and condition	Capacity	Best Practicable Technology				Best Available Technology			
		Invest-ment	Ex-penses 1/	Depreci-ation	Interest	Invest-ment	Ex-penses 1/	Depreci-ation	Interest
	(1,000 TPY)	---$1,000---				---$1,000---			
Ammonia	50	129	94	13	5	87	31	9	3
	105	183	133	18	7	122	35	12	5
	210	256	191	26	10	171	41	17	6
	350	332	252	33	12	222	48	22	8
	525	424	325	42	15	283	55	28	11
Ammonium nitrate	105	542	362	54	20	141	40	14	5
	160	688	483	69	26	178	46	18	7
	350	1,007	639	101	38	249	63	25	9
Urea	52	190	115	19	7	124	47	12	5
	105	268	163	27	10	173	54	17	6
	160	332	206	33	12	216	63	22	8
	350	521	335	52	20	338	87	34	13
Diammonium phosphate (no liming in place)	170	1,375	720	138	52	259	45	26	9
	330	1,586	877	159	59	321	50	32	11
	720	2,103	1,188	210	80	532	74	54	20
Diammonium phosphate (double liming in place)	170	999	537	101	38	259	45	26	9
	330	1,210	694	121	45	321	50	32	11
	720	1,727	1,005	173	63	532	74	54	20

continued..... .

Table B-3 (continued)

		Best Practicable Technology				Best Available Technology			
Product and condition	Capacity	Investment	Expenses 1/	Depreciation	Interest	Investment	Expenses 1/	Depreciation	Interest
	(1,000 TPY)	$1,000				$1,000			
Triple superphosphate	170	962	327	96	36	137	14	13	5
(no liming in place)	330	1,028	339	103	39	173	17	17	6
Triple superphosphate	170	586	144	59	22	137	14	13	5
(double liming in place)	330	652	156	65	24	173	17	17	6

1/ Excludes depreciation and interest.

2/ Includes chromate removal, biological treatment, pond-water sulfuric acid dilution and DAP self-contained. Also, ion exchange is included at the BPT level for the ammonium nitrate segment.

Table B-4. Estimated incremental investment and annual costs for BPT and BAT effluent controls 2/ in model plants exclu
ing chromate control and biological treatment in nitrogen segments

Product and condition	Capacity	Best Practicable Technology				Best Available Technology			
		Investment	Expenses 1/	Depreciation	Interest	Investment	Expenses 1/	Depreciation	Interest
	(1,000 TPY)	$1,000				$1,000			
Ammonia	50	100	90	10	4	41	4	4	2
	105	141	125	14	5	57	5	6	2
	210	198	176	20	8	80	7	8	3
	350	256	228	26	10	104	10	10	4
	525	327	290	33	12	132	12	13	5
Ammonium nitrate	105	494	352	49	19	63	6	6	2
	160	625	469	62	24	82	8	8	3
	350	914	610	91	35	117	11	12	4
Urea	52	148	108	15	6	58	6	6	2
	105	208	151	21	8	81	7	8	3
	160	258	187	26	10	121	10	12	5
	350	405	297	40	15	158	15	16	6
Diammonium phosphate (no liming in place)	170	1,291	701	129	49	225	23	22	9
	330	1,475	845	148	55	274	27	27	10
	720	1,913	1,122	191	73	459	46	46	17
Diammonium phosphate (double liming in place)	170	915	518	92	35	225	23	22	9
	330	1,099	662	110	41	274	27	27	10
	720	1,537	939	154	58	459	46	46	17

continued--

Table B-4 (continued)

Product and condition	Capacity	Best Practicable Technology				Best Available Technology			
		Investment	Expenses 1/	Depreciation	Interest	Investment	Expenses 1/	Depreciation	Interest
	(1,000 TPY)	---------------$1,000				---------------$1,000			
Triple superphosphate (no liming in place)	170	917	314	92	34	137	14	13	5
	330	967	317	97	36	173	17	17	6
Triple superphosphate (double liming in place)	170	541	131	54	20	137	14	13	5
	330	591	134	59	22	173	17	17	6

1/ Excludes depreciation and interest.

2/ Includes pond-water sulfuric acid dilution and DAP self contained. Also, ion exchange is included at the BPT level for the ammonium nitrate segment.

Table B-5. **Estimated cash flow and net present values for model plants without and with effluent controls--with expected price adjustment**

Model Plant	Capacity	Base			BPT					
		Cash Flow	Net Present Value		Cash Flow	Net Present Value		Cash Flow	Net Present Value	
			6.0	7.0		6.0	7.0		6.0	7.0
	(1,000TPY)	----------	----------	----------	----------	$1,000	----------	----------	----------	----------
Ammonia	50	-97	-3,233	-3.099	-124	-2,624	-2,624	-135	-2,749	-2,605
	105	395	539	381	408	442	280	421	430	264
	210	1,542	9,647	8.833	1,577	9,657	8,829	1.603	9,689	8,850
	350	2,804	17,748	16,296	2,894	18,214	16,713	2.946	18,352	16,827
	525	4,442	31,585	29,130	4,603	32,636	30,087	4.687	32,907	30,377
Ammonium nitrate	105	355	9	-101	163	2,134	-2,131	188	-2,077	2,085
	160	866	3,737	3,336	763	1,785	1,477	799	1,869	1,545
	350	2,904	18,844	17,313	2,782	17,304	15,823	2,877	17,633	16,109
Urea	52	-655	-8,998	-8,498	-674	-9,714	-9,176	-682	-9,660	-9,132
	105	557	1,333	1,109	589	1,297	1,062	612	1,314	1,068
	160	1,222	6,238	5,638	1,290	6.479	5,846	1,334	6,576	5,926
	350	3,582	24,867	22,871	3,784	26,212	24,104	3.923	26,734	24.561
Diammonium phosphate (No liming in place)	170	2/	2,341	1,351	2/	-904	-1,288	2/	-1,142	-1,512
	330	2/	14,767	12,986	2/	13,639	11,809	2/	13,357	11,543
Diammonium phosphate (Liming in place)	170	2/	2,341	1,351	2/	339	-177	2/	75	-426
	330	2/	14,767	12,986	2/	15,103	13,190	2/	14,821	12,924
Triple superphosphate (No liming in place)	170	2/	3,471	3,014	2/	1,101	723	2/	999	627
	330	2/	10,371	9,144	2/	8,851	7,654	2/	8,729	7,539
Triple superphosphate (Liming in place)	170	2/	3,471	3,014	2/	2,734	2,282	2/	2,633	2,185
	330	2/	10,371	9,144	2/	10,315	9,044	2/	10,193	8,929

1/ Exclusion of Ion Exchange technology yields the following results:

	Capacity (1000 TPY)	Cash flow	BPT Net Present Value		Cash flow	BPT and BAT Net Present Value	
			6.0	7.0		6.0	7.0
Ammonium nitrate	105	367	- 133	- 245	387	- 117	- 235
	160	900	3,737	3,322	936	3,820	3,390
	350	2,940	19,703	18,097	3,035	20,048	18,398

2/ Varies by year. See Table VI-5.

Table B-6. Estimated cash proceeds for selected phosphate plants--with expected price adjustment

				No lime in place		Lime in place	
Plant	Capacity	Year	Base	BPT	BPT & BAT	BPT	BPT & BAT
	(1,000 TPY)		$1,000				
Diammonium phosphate (No liming in place)	170	1977	-575	-1,123	-	-926	-
		1978	-197	-735	-	-538	-
		1979	109	-379	-	-182	-
		1980	681	211	-	408	-
		1981	303	886	-	972	-
		1982	202	710	-	880	-
		1983	745	-	1,335	-	1,420
Diammonium phosphate (Double liming in place)	330	1977	-315	112	-	267	-
		1978	225	1,103	-	1,230	-
		1979	555	1,535	-	1,601	-
		1980	1,135	2,143	-	2,209	-
		1981	804	1,835	-	1,902	-
		1982	1,742	2,792	-	2,858	-
		1983	2,797	-	3,853	-	3,920
Triple superphosphate (No liming in place)	170	1977	-49	-280	-	-97	-
		1978	200	-29	-	154	-
		1979	359	168	-	351	-
		1980	634	587	-	661	-
		1981	399	352	-	429	-
		1982	202	149	-	226	-
		1983	618	-	576	-	653
Triple superphosphate (Double liming in place)	330	1977	17	-111	-	42	-
		1978	272	242	-	319	-
		1979	440	451	-	528	-
		1980	33	-2	-	125	-
		1981	601	624	-	700	-
		1982	1,173	1,200	-	1,277	-
		1983	1,978	-	2,012	-	2,089